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Prof. S. F. Baird
with the kind regards
of J. S. Newberry

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REPORT

OF THE

GEOLOGICAL SURVEY OF OHIO.

VOLUME I.

GEOLOGY AND PALÆONTOLOGY.

PART II. PALÆONTOLOGY.

OFFICERS OF THE SURVEY:

J. S. NEWBERRY,	Chief Geologist.
EDWARD ORTON,	Assistant Geologist.
E. B. ANDREWS,	Assistant Geologist.
T. G. WORMLEY,	Chemist.
F. B. MEEK,	Palæontologist.

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PREFACE.

The present volume contains the first part of the Palæontological Report of the Geological Survey of Ohio, and the first illustrated memoir ever published on the fossils of the State. Ohio, with its great breadth of surface and diversity of geological structure, is one of the richest fields for the palæontologist known, and during the last forty years its Silurian, Devonian and Carboniferous strata have furnished a very large number of well marked fossils, most of which have gone to enrich the cabinets of other States and countries. The exposures of the Lower Silurian rocks about Cincinnati deserve special mention, from the variety and beauty of the organic remains which they yield. This locality has now a world-wide fame, and it has supplied suites of beautifully preserved fossils which form the pride of many cabinets in Europe as well as in our own country. The Corniferous limestone and the Waverly group have also contributed a large number of fossil mollusks, crustaceans and corals to the collections made in our State by resident or foreign geologists.

The Devonian and Carboniferous rocks have proved to be rich in fossil fishes, and the latter in Batrachians and plants. Collections of all these have been made by the writer, which in variety and interest are not surpassed by those derived from the Palæozoic formations of any country.

Among the fossils obtained by others in former years from these different formations, many proved to be new to science, and a large number of them have been described by Profs. Hall, Winchell and Meek. The descriptions of these species are, however, widely scattered through the various media for the publication of scientific material, and are accessible to but few of our citizens. In many instances, too, the descriptions were published without figures, so that it has been almost impossible for our students of geology to determine accurately the names and the relations of the fossils they have collected. As fossils constitute the most reliable data for the identification of strata, the difficulty which has been experienced in obtaining accurate information about those found in this State has not only retarded the progress of geological knowledge among our people, but has occasioned much difference of opin-

ion and prolonged discussion among geologists in regard to the equivalence of our rocks. When the present Geological Survey was organized, it therefore became one of the most important duties of the Corps to make systematic collections of the fossils of the different formations; to read from them the lessons they might teach, and to publish such figures and descriptions as would enable our teachers and students to identify them, and apply them to their legitimate uses. The first part of this duty has been done. A sufficient number of fossils has been gathered from all the fossiliferous rocks to enable us to make out satisfactorily the geological structure of the State, and to settle all the questions that have been raised in regard to the relations of our strata to those that have been studied and named in other States and countries. They have thus rendered us indispensable assistance in the acquisition of the information conveyed in our geological reports.

The second part of the task assigned us, is in part performed by the publication of the present volume. In order to give the greatest possible accuracy and value to the review of our palæontology, which was expected as one of the results of the Geological Survey, it was necessary to invoke the aid of several specialists. The different classes of fossils collected by the members of the Geological Corps, and such as, gathered in former years, were accessible to us, were committed for study to persons who had given special attention to one or another of the different departments of palæontology. The *invertebrate* fossils were assigned to Mr. F. B. Meek, one of our most learned and accurate scientists, who, in addition to other labors by which he had gained a well deserved reputation, had for several years been acting as palæontologist to the Illinois Geological Survey, and had thus become critically familiar with the invertebrates of the Palæozoic formations of the Mississippi Valley. The greater part of the matter contained in the palæontological portion of the present volume has been supplied by Mr. Meek, and forms the first installment of his report upon the materials placed in his hands.

Prof. James Hall, the distinguished palæontologist of New York, who had characterized and named a large number of fossils from this State, also consented to contribute to our reports descriptions and figures of such Ohio fossils as he had already described, or held waiting examination in the rich stores of his magnificent collection. The matter to be furnished by Prof. Hall is promised for our next volume on Palæontology.

The *Amphibian* remains—of which nearly twenty species, all new to science, had been obtained from the Coal Measures before the organization of the present Survey—were committed to Prof. Edward D. Cope, who stands in the front rank of living comparative anatomists. His report on these interesting fossils is nearly ready, and will form

part of our second volume. As it will more than double the number of genera and species known in the Batrachian fauna of the Coal Measures, it cannot fail to prove an important contribution to science.

The description of the *fossil fishes* and *fossil plants* was assumed by the writer, who had for many years made them objects of special study, and who had in his collections nearly everything of interest in these departments which had been obtained in the State during the last quarter of a century. A partial report on this material is made in the present volume. The discussion of the remainder will be reserved for future publication.

In the law providing for a Geological Survey of Ohio, the Geological Corps was required, first, to make the survey, and when that should be completed, to embody the results in a Final Report, but it has been thought by the Geological Board wiser not to wait the completion of the field work before publishing in permanent form any portion of the results. As a consequence, this volume is given to the public, while as yet much of the matter which is to form future volumes remains to be accumulated. If it had been possible to gather and prepare all the material to be used, before the publication of any part of it, it would have been easy to arrange it in such a way that all the facts related to each other should be grouped together; but this is not now entirely practicable. An effort has been made, however, to give as great system to our report as could be done under the circumstances. In the Geological portion of this volume, after a general review of the Physical Geography and Geological Structure of the State had been given, a more detailed description of the Silurian and Devonian Systems was presented; while the discussion of the Carboniferous and Drift formations was postponed. So far as possible a parallel course has been followed in the accompanying report. Figures and descriptions are now given of only the Silurian and Devonian invertebrates; the Carboniferous mollusks, crinoids and corals remaining for publication hereafter. In the arrangement of the descriptions of the vertebrate fossils and fossil plants, such an arrangement was scarcely practicable, inasmuch as most of these are derived from the Carboniferous System; and if no Carboniferous fossils were admitted into this volume, our materials would be very unequally divided. An arrangement *by subjects* has therefore been adopted, so far as relates to these fossils, and one which will perhaps be equally acceptable. In this volume the fossil fishes are reviewed collectively, and while some material in this department will remain to be included in another volume, no general discussion of the zoological relations and geological distribution of our fossil fishes will be attempted there. On the other hand, the interesting group of amphibians found in our Coal Measures are altogether reserved for another volume, where they will be described

in detail, and will supply figures for perhaps ten plates. The description of the fossil plants will also be mainly deferred. A few species of unusual interest—for which drawings and descriptions have been prepared for many years—are published in this volume, to give variety to its contents, and to divide more equally the materials in hand. But most of the matter prepared in this department will be reserved until it can form part of a general review of our fossil plants, similar in scope to the synopsis of our fossil fishes now published. In that report the plants of our different formations will be described in order, beginning with those of the Lower Silurian; and the progress of plant life will, as far as practicable, be traced through the successive geological ages.

The State of Ohio, with its 88 counties and 39,964 square miles, presents so wide a field for geological exploration, that the time of the Geological Corps has been mainly occupied in the study of the general and local geological structure and economic geology. A large number of fossils have, however, been collected in the prosecution of our work, and in a few instances they have been made objects of special search; but the accumulation of good material in any department of palæontology is generally a matter of time and patient waiting for the results of mining, quarrying, etc., and it is only to be rapidly obtained by a large outlay of money. As we have not felt justified in the expenditure of much time or money for making collections of fossils beyond what were required for geological purposes, we should now be able to present to the public but little new and interesting palæontological matter if we had not been permitted to avail ourselves of the fruits of other labors than our own. Fortunately for the interest and value of our reports, during the long interval which has elapsed since the suspension of the former Geological Survey, the collectors of Ohio fossils have not been idle; and though much of the material which would be most fitly presented to the public through the medium of the Geological Survey has been lost, scattered or described elsewhere, at the beginning of our Survey we found such an amount of new material in the hands of private parties as would in itself, if properly illustrated, greatly embellish and enrich our Report. Through the courtesy of the holders of this material, most of it has been made available for our use, and this, with the collections made by the Geological Corps, forms an array of new matter which we venture to hope will be of interest to the public.

In the preceding notes reference is made only to the fossils of the bedded rocks; but there are some other organic remains found in the State, which, though much more modern, still belong to a former age, and are the legitimate and by no means the least interesting objects of investigation by the palæontologist. In the superficial

deposits many interesting mammalian remains have been brought to light in the prosecution of public works—railroads, canals, etc.—and more especially in the excavations for the drainage of swamps and peat marshes. Of these, the most striking are the bones, teeth and tusks of the Elephant and Mastodon. In nearly every county of the State relics of these huge mammals have been exhumed, and in some instances nearly the entire bony structure has been found. In most cases, however, the bones have been broken up and scattered, and nothing like a complete skeleton has in any case been preserved. Most of these remains were met with in former years, but even since the organization of the Geological Survey, some important discoveries of this kind have been made. As before, however, ignorance or carelessness has prevented the preservation of material which, if it could have been saved from violence or decomposition, would have been of the greatest scientific value. An earnest effort has been made to secure all possible facts and specimens which could serve to illustrate the occupation of our territory by these great animals, and whatever information we may be able to gather on this subject, will be recorded in the future publications of the Survey.

I should also refer here to the discovery of the bones of the giant Beaver (*Castoroides Ohioensis*), which was first described by Col. J. W. Foster in the Second Annual Report of the former Geological Corps (1838). Some other remains of this remarkable animal have since been found, and it is proposed to present, in a future report, all the facts that can be gathered in regard to it, with figures of such portions of its structure as are now extant.

Fragments of the bones of the large wild hog (*Dicotyles compressus*)—which once inhabited Ohio, but is now entirely extinct—have in several instances been found in our own and adjoining States. A most important discovery of this kind has recently been made at Columbus; and, thanks to the intelligent care of Mr. J. H. Klippart, who took great pains to preserve them, nearly complete skeletons of twelve individuals of this species of peccary have been secured for study and description. As only a small portion of the bony structure of this animal was before known, the discovery to which I have referred will add very much to our knowledge of it, and will furnish some interesting material to our palæontological reports.

Acknowledgments are elsewhere made of our obligations to some of those who have contributed to the attractiveness and value of our reports, but it is eminently proper that I should here repeat the names of Messrs. C. B. Dyer, U. P. James, S. A. Miller, S. T. Carley, David H. Shaffer and Dr. Miller, of Cincinnati; Rev. H. Hertzer, now of Louisville, Ky.; J. K. O'Neall, Esq., of Lebanon, Ohio; Dr. A. H. Agard and L. P. Wheelock, of Sandusky; Jay Terrell, Esq., of Elyria, and Prof. George N.

Allen, of Oberlin; all of whom have generously given us the use of the materials in their hands, the fruits of many years of patient and assiduous collection.

The fossil fishes, amphibians and plants which will be described in this and other volumes of our Report, were mostly obtained by the writer before the commencement of the Geological Survey, and the originals of the descriptions published by Prof. Cope and myself now form part of the collections of the School of Mines of Columbia College, New York. So far as practicable, specimens of the species described will be placed in the cabinet of the Ohio Agricultural and Mechanical College and in the Museum of the Smithsonian Institution. Where the specimens are unique, they will be found in the cabinet of the School of Mines. All the material gathered by the Geological Corps becomes, by special act of the Legislature, the property of the Ohio Agricultural and Mechanical College, and may be referred to in the cabinet of that institution.

I may be permitted to express here a regret that no fire-proof repository has been provided by the State of Ohio for the specimens collected on the Geological Survey, as the destruction by fire of material not so protected seems to be only a question of time. The *type* specimens—such as have served as the basis of chemical, geological and palæontological description—have a special, and, in some instances, an inestimable value. Their loss is frequently a public calamity, and a large part of the confusion which exists in the records of natural science is due to the destruction of such standards of reference. The best specimens obtained in any State should, if possible, be fixed in some safe and accessible repository at the State Capital, or in some institution of learning that can provide accommodations for them, where they will not be exposed to theft or fire, and where they may be at all times readily accessible to those who desire to consult them. Such specimens are not merely objects of curiosity, but they constitute a kind of library in which knowledge of the greatest scientific importance is recorded. They differ from books, however, in this, that many of them are *unique copies*, and when lost, can never be replaced. In this respect they are more like legal documents and public archives, and should be preserved with the same care. The importance of these considerations has been recognized in several of the States of our Union—as in New York, Illinois, etc.—where special provision has been made in the construction of public buildings for the reception and display of the collections of the Geological Surveys, and for the safe preservation of the type specimens described in the Reports.

The illustrations which accompany the descriptive matter of this volume will generally commend themselves by the accuracy and beauty of their execution, and it is

but just that the artists who have so ably seconded the efforts of the palæontologists, should receive honorable mention in this connection.

The drawings of the crustaceans, mollusks and crinoids, of which figures are now published, were for the most part made by Mr. W. H. Holmes.

The fossil plants and the Carboniferous fishes were drawn by Mr. T. Y. Gardner, and form part of the series of plates prepared by the writer before the beginning of the Survey, and which have been supplied without cost to the State.

The plates of Devonian fishes were drawn by Mr. G. K. Gilbert, for two years an assistant on the Survey of Ohio, and now Chief Geologist of the Government Surveys in Colorado, Arizona and New Mexico, under Lieut. G. M. Wheeler, U. S. A.

The engraving of our plates has been mostly done on stone by Messrs. T. Sinclair & Son, of Philadelphia, who are making a specialty of palæontological illustrations. By securing the services of trained and skillful lithographers, they have done our work in a style and with a degree of promptness that deserve special commendation. I should also say that the courtesy of Mr. Sinclair, and his cordial co-operation in our efforts to secure accurate and tasteful copies of our drawings, have contributed much to the results attained.

J. S. Newberry.

Columbus, Ohio, *January 1st*, 1873.

GEOLOGICAL SURVEY OF OHIO.

VOL. I. PART II.

PALÆONTOLOGY.

SECTION I.

DESCRIPTIONS OF INVERTEBRATE FOSSILS OF THE SILURIAN AND DEVONIAN SYSTEMS.

BY

F. B. MEEK.

To Dr. J. S. Newberry, *State Geologist:*

Dear Sir: In respectfully submitting this Report on some of the Invertebrate fossils of Ohio, I desire to acknowledge here my obligations to the following gentlemen for the loan of numerous fine specimens from the Cincinnati rocks, viz: Messrs. C. B. Dyer, U. P. James, S. A. and Dr. Miller, D. H. Shaffer, and Drs. Hill and Byrnes. To Mr. James and Mr. Dyer, as well as to some of the others, I am likewise indebted for much interesting information in regard to the vertical range, etc., of the species and varieties in the Cincinnati beds. These gentlemen have been collecting the fossils of this exceedingly rich locality for many years past, and now possess extensive and valuable collections, from which they generously allowed me to select any specimens I wanted for study or illustration. Some of those thus borrowed from Mr. Dyer, are types of species described by others, but not hitherto figured.

I am also under obligations to the Rev. Mr. H. Hertzer, and Prof. Edward Orton, of the Ohio Survey, for the loan of some interesting Devonian and Upper Silurian fossils, belonging to their own private collections, from near Columbus and Yellow Springs, Ohio.

Among parties living out of the State, to whom I am indebted for the loan of specimens for comparison and study, I would mention Prof. C. F. Hartt, of Cornell University, New York; Prof. Oliver Marcy, of Evanston University, Illinois; Prof. Frank H. Bradley, of Knoxville University; Dr. E. Billings, of Montreal, Canada; Dr. I. A. Lapham, of Milwaukee, and Dr. F. H. Day, of Wamatosa, Wisconsin.

I am also under special obligations to Prof. Joseph Henry, for important facilities at the Smithsonian Institution, during the preparation of this Report.

It is due to myself to remark here, that I have labored under the disadvantage of having to form conclusions in regard to the relations of many Ohio forms to species that have been described by others from this and adjoining States, without having typical or well authenticated examples of the named species for comparison. This difficulty was most particularly felt in the study of the fossils from the Devonian and Upper Silurian beds, from which many species have been described (often very briefly), and either not yet figured at all, or only imperfectly illustrated.

Very respectfully yours,

F. B. Meek.

Smithsonian Institution,
Washington City, D. C., Feb. 7, 1873.

FOSSILS OF THE CINCINNATI GROUP.

RADIATA.

ECHINODERMATA.

*CRINOIDEA.**

Genus HETEROCRINUS, Hall, 1847.

(Palæont., N. Y., vol. 1, p. 278.)

In first publishing this genus, Prof. Hall illustrated it as having only a single range of body pieces below the radial series, and without anal plates or pinnulæ. Species subsequently described by Mr. Billings, and others by the writer and Mr. Worthen, however, show that it has a well-developed anal series, and that the arms are often, though not always, provided with pinnulæ. Still more recently, Prof. Hall (see his Descriptions New Sp. Crinoidea, p. 4, dated 1866) called attention to the presence, in some species of this genus, of five very minute pieces at the connection of the column with the body; one being placed directly at the lower end of each suture dividing the first range of well developed body-plates. These minute pieces he views as true basals, and the range just above them, that have always been regarded as the basals, he considers sub-radials—thus making the genus have both sub-radial and basal pieces.

I have some doubts, however, in regard to the propriety of this view of these parts, not only because the minute pieces at the head of the column are sometimes entirely wanting, and never so much developed

* It may be proper to mention here, that some recent investigations of the soft parts of *Comatula*, by Prof. Metschnikoff, of St. Petersburg, seem to render it very doubtful whether the *Crinoidea* really belong to the Class *Echinodermata* at all, as generally believed. At any rate, he could find no traces whatever, in *Comatula*, of the water system of the *Ophiurians*, Star-fishes, *Echini* and *Holothurians*. (See Bull. Acad., St. Petersburg, XV., p. 508, Feb'y, 1871; and Am. Naturalist, Vol. VI., May, 1872, p. 305.)

as to form a contiguous range of pieces all around; but also, because they correspond exactly in size and form, and in their vertical range, with five others often seen intercalated between each two of the discs of the column for some distance below the body. In this, as in some other genera, particularly of Silurian age, the column is always equally divided, longitudinally, into five sections, so that each of its discs is really composed of five distinct pieces, which, however, frequently become anchylosed together. The more minute pieces mentioned above are also always placed exactly at the dividing lines between each two of the five larger ones composing each disc of the column, and thus form rows exactly coincident, vertically, with those at the head of the column. Farther down the column, these minute pieces become more and more extended laterally, until finally they connect with each other, and thus themselves form discs—at first thinner than those with which they alternate, but still farther down the column, they become, in part at least, of the same size as the latter. (See fig. 3 *a*, pl. 1.) From these facts, I am inclined to think the very minute pieces at the immediate connection of the column with the body, should rather be viewed as belonging to the column, than as true basals. I have, therefore, in describing the species in which these minute pieces exist, always called them sub-basal pieces, and the well developed range above, basals.

In the paper above quoted, Prof. Hall, in speaking of these minute sub-basals in this genus, also remarks, that, if they were "developed, the structure would be the same as in *Poteriocrinus;* and in the absence of these plates, those which are the sub-radials in that genus, become the basal or lower series." It seems to me, however, that even if these minute pieces in this genus were large enough to assume the character of true basals, the structure of the genus would still be constantly distinct from that of *Poteriocrinites*, in the number and arrangement of its anal pieces. In *Poteriocrinus*, the anal pieces always rest directly down upon the sub-radials, and generally consist of two vertical rows of alternating pieces, the lowest piece being often, as it were, wedged down obliquely, partly under the first radial on the right; while in *Heterocrinus*, there is always but a single row of true anal pieces, the first or lowest one of which, instead of resting down upon the range of pieces that would, according to Prof. Hall's view, correspond to the sub-radial pieces in *Poteriocrinus*, actually rests upon one of the sloping sides of the *second radial* on the right, and partly upon the first radial on the left. This structure seems to be constant in all the species, and imparts so singular an appearance to the anal series, that they have generally been mistaken by Prof. Hall for an arm.

Heterocrinus constrictus, Hall.

Plate 1, figs. 10 *a*, *b* (and 11 ?).

Heterocrinus constrictus, Hall, ———; Illustrations of a paper entitled "Descriptions New Sp. Crinoidea," etc., dated 1866, pl. 1, fig. 3 (without description).

Body short sub-cylindrical, or slightly tapering below, and distinctly constricted just below the arm-bases above. Sub-basal pieces wanting, or only appearing as minute, imperfectly developed divisions of the last joint of the column, without modifying the form of the basals. Basal pieces wider than long, sub-pentagonal in form, the mesial angle above being scarcely perceptible. Radial pieces of unequal size and form; the first one in the left posterior lateral ray about as long as wide, and sub-pentagonal in form (its right superior lateral angle being a little truncated), while it supports above, a shorter quadrangular piece, which bears on its upper edge a still shorter, but wide pentagonal axillary piece, upon which the arms rest; anterior, and right anterior lateral rays, having the same number, form and proportions of pieces; left anterior lateral ray composed of four primary pieces, the first of which is pentagonal, and about as long as wide, the second as wide as the first, but much shorter, and quadrangular in form, the third quadrangular and nearly as long as wide, and the fourth very short, pentagonal, and bearing two arms on its upper sloping sides; right posterior ray composed of five primary, or body pieces, the first one of which is wider than long, and pentagonal in form, the second much shorter than wide, and sub-pentagonal, the third about the size of the first, but quadrangular, the fourth very short, and the fifth wider than long, pentagonal in form, and, like the last piece in each of the other two rays, bearing above, two arms. First anal piece, as usual, resting between the lateral superior sloping sides of the first piece of the left posterior ray, and the second of the right, and connecting on each side with the succeeding pieces of these rays above, while it appears to support one or two other smaller pieces in direct succession above.

Arms ten, stout, rounded on the dorsal side, and simple from their origin on the last radial pieces; composed of short wedge-formed pieces, about every third one of which is thicker than the others, and supports on the upper lateral sloping side of its thicker end, a stout pinnule or small armlet, that does not diverge from the arm, but lies close and parallel to the sides of the latter, when they are folded together; armlets thus arranged alternately on each side of the arms, and apparently

sometimes themselves bearing smaller secondary divisions. Surface nearly smooth, or only finely granular.

Height of body to the top of the last radial pieces, 0.30 inch; breadth at same point, allowing for accidental compression, 0.34 inch; breadth at the point of constriction, 0.29 inch; breadth of base at its connection with the column, 0.21 inch; thickness of arms near their bases, about 0.10 inch.

The foregoing description and measurements, as well as our figures 10 *a*, *b*, of plate 1, were prepared from Prof. Hall's typical specimen belonging to Mr. Dyer's collection. Another specimen belonging to Mr. Dyer, now before me, and represented by fig. 11, of the same plate, has a somewhat different aspect, and was, at one time, believed to be a distinct species, but as it seems to agree exactly in structure, so far as we have the means of comparison, it is most probably only a variety of the same species. Its chief differences consist in the possession of rather decidedly less robust and less rounded arms, and a proportionally narrower body, that tapers less below. In the typical specimen, the column and the upper part of the arms are broken away, so that these parts cannot be compared with those of the specimen mentioned above. In the latter the arms are of moderate length, scarcely tapering, excepting near their free ends, and when folded together, present the appearance of a sub-cylindrical bundle, of about twice the breadth of the body below. Its column is quite stout, being nearly as thick as the body, near which it is round and composed of alternately thicker and thinner pieces. Between the upper one of these and the base, fine, thin, small pieces can be seen, that do not truncate the corners of the basals, and present the appearance of the elements of a thin joint of the column, not yet coalesced so as to form a single segment. Similiar but somewhat larger pieces are also intercalated between the first and second segments of the column below.

In the form and structure of the body, this species is related to *H. juvenis*, and less closely to *H. heterodactylus*, of Hall; but it is very much larger, and more robust than either, and differs in having its column rounded instead of pentagonal. It likewise differs very materially from the former, as well as from the western form that has always been referred to *H. heterodactylus*, in having its arms simple instead of bifurcating.

From *H. simplex*, which has simple arms, it will be readily distinguished by its larger size, more robust habit, proportionally much larger column, and less tapering and peculiarly constricted body. Its

arms are also much stouter, and its pinnulæ, or armlets, proportionally larger.

Locality and position: About 100 feet below the tops of the hills at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian. Mr. Dyer's collection.

Heterocrinus exilis, Hall?

Plate 1, fig. 12.

Heterocrinus exilis, Hall, ——; "Descriptions New Sp. Crinoidea," etc., p. 6, dated Nov., 1868; and re-issue same (1872), pl. 1, fig. 16.
Heterocrinus exiguus, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., Jan'y, p. 308.

Body small, obconoidal, or tapering from above to the column, near which it becomes pentagonal in consequence of the flattened surface of each of the basal pieces. Sub-basal pieces obsolete, or very minute. Basal pieces (sub-radials of some) of moderate size, about as wide as long, pentagonal, and almost perfectly flat. Left posterior ray bifurcating first on the fifth piece, the first piece being comparatively large and irregularly hexagonal, in consequence of having a short sloping side on its upper right edge for the reception of one side of the first anal piece; the four succeeding pieces much narrower, about as long as wide, and rounded, and more or less constricted in the middle, with expanded upper and lower ends. Right posterior ray bifurcating first on the eighth piece, the first piece being decidedly smaller than that of the left posterior ray, pentagonal in form, and slightly longer than wide; while the second is of the same breadth, but shorter, rounded on the dorsal side, and irregularly pentagonal in form, the fifth angle being formed by a short side on the left above, for the reception of the first anal piece; succeeding pieces, about as long as wide, or slightly longer, rounded and constricted in the middle, and expanded at the ends. Right anterior lateral ray bifurcating first on the sixth piece, the first piece being distinctly larger than the others, apparently a little longer than wide, and sub-pentagonal in form; while those above are smaller, and of the same form as the corresponding pieces of the other rays described. (Other rays unknown.) Arms very long, slender, and bifurcating at least four times, at irregular distances above the first divisions of the rays; pieces of the lower divisions generally longer than wide, rounded and constricted in the middle, and expanded at the ends; while those of the smaller terminal divisions are usually from three to four or five times as long as wide, and scarcely expanded at the ends. Surface smooth. Pinnulæ not seen.

First anal piece small, about as long as wide, and, as usual, resting

between the superior sloping sides of the first radial on the left, and the second on the ridge, and bearing three or more others in direct succession above, that doubtless form a part of the walls of the ventral extension.

Column small, distinctly pentagonal near the base, where it is composed of alternately thin, and slightly thicker pieces.

Length of body to top of the larger radial pieces forming a part of its walls, 0.14 inch; breadth, about 0.12 inch; length of rays and arms above the body, 1 inch; thickness of column near base, about 0.07 inch.

In describing this form in the Proceedings of the Academy (under the names *H. exiguus*), I mentioned that it seemed to be closely allied to *H. exilis*, Hall (which had not at that time been figured), and might possibly belong to that species, but added, that "if Prof. Hall's description [of *H. exilis*] is strictly accurate, however, in several important characters, the form under consideration must be clearly distinct, as he states that the posterior lateral rays of *H. exilis* bifurcate on the *second* piece, and the anterior lateral on the fourth; while in the form here described, one of the posterior lateral rays bifurcates first on the *fifth* piece, and the other on the *eighth*, and in the only one of the lateral rays seen, the first division takes place on the *sixth* or *seventh* piece." I farther remarked, that "he also says that the arms of *H. exilis* bifurcate *once* or *twice;* while in our type, they bifurcate at least four times above the primary division of each ray. Again he describes the body plates of *H. exilis* as having the general curve of the body; but in our type the sub-radial (more properly the basal) plates are flattened so as to impart a pentagonal form to the lower part of the body."

Since this was printed in the Proceedings of the Academy, I have seen a figure of Prof. Hall's species, on a plate accompanying a re-issue of the paper containing his original description. The impressions of this plate illustrating this re-issue seem to have been taken when it was in an unfinished condition, and do not show the arrangement of the parts very clearly; but as nearly as I can make them out, the right posterior lateral ray certainly is not represented as bifurcating on the second piece at all, though, like other species of the genus, it supports an arm-like ray of *anal pieces*, on the left superior sloping side of the first or second piece (it looks as if on the first, in the figure), while three other radials are seen in direct succession above the one supporting the anal series (and a fourth is represented in outline in a part of this ray restored) before the first true bifurcation takes place. Again, in the left posterior lateral ray, there are *four* pieces represented in the figure, in direct succession below the first bifurcation; while, including restorations in outline, of portions

of the arms, there are clearly represented at least three bifurcations in some of the rays, instead of one or two, as stated in the description.

Since seeing this figure, I am strongly inclined to believe the form here under consideration is identical with Prof. Hall's species, though in consequence of the discrepancies between his figure and description, and the rather unfinished condition of the former, I am left in doubt on this point.

This form will be at once distinguished from *H. simplex* by its frequently bifurcating arms, and other well marked characters. From the western form that has generally been referred to *H. heterodactylus*, which also has its arms bifurcating several times, it may be distinguished by the very different form of its body, its much more slender arms, with more frequent divisions, and greater length, as well as by its more slender column.

Locality and position: Cincinnati group, at Cincinnati, Ohio, where it occurs at the horizon of about 100 feet below the top of the hills. Mr. Dyer's collection.

Heterocrinus simplex, Hall.

Plate 1, figs. 4 *a*, *b*; 5 *a*, *b* (with 6 *a*, *b*, and 7 *a*, *b*, *c*?)

Heterocrinus simplex, Hall, 1847; Palæont. N. Y., vol. 1, p. 280, pl. lxxvi., fig. 2 *a*, *b*, *c*, *d*; Hall (1872), pl. I., figs. 11 and 12, accompanying a re-issue of his paper on New Crinoidea, etc., dated Nov., 1866.

H. Canadensis, Billings, 1859; Canadian Organic Remains, Dec. IV., p. 48, pl. IV., fig. 5 *a*–5 *d*.

Body small, obconic, or tapering regularly from above to the column, as long as wide, or a little longer. Sub-basal pieces undeveloped. Basal pieces of moderate size, about as wide as high, one regularly pentagonal, and four irregularly so. First radial pieces in three of the rays, small and short, being decidedly wider than long, and pentagonal in form; each supporting on its rather broadly truncated upper side a second radial of considerably larger size, generally longer than wide, and quadrangular in form, excepting one on the anal side, which has one of the superior lateral angles truncated so as to present a pentagonal outline; third radials in these rays smaller than the second, wider than long, with a quadrangular form, and each supporting a somewhat larger, pentagonal fourth radial, which is an axillary piece, and bears two arms on its superior sloping sides. First radials in the other two rays comparatively large, as long as wide or longer, one hexagonal and one heptagonal (there being no mesial angle at the base), and each supporting a smaller short, transversely oblong, second radial, above which there is in each of these

rays a slightly larger third radial of pentagonal form, that bears on its superior sloping sides two arms.

First anal piece about as wide as long, pentagonal in form, and resting between the short superior sides of the first piece in the left and the second piece of the right posterior rays; second anal supported on the upper side of the first, quadrangular in form, and surmounted by a third smaller trigonal or sub-pentagonal piece, immediately above which the arms close together so as to hide any succeeding parts connecting these with the ventral prolongation.

Arms above their origin on the third and fourth radials, simple, rather long, somewhat flattened on the dorsal side, and composed of a single series of pieces that are usually about as long as wide, but alternately longer on one side than on the other, and bearing on each inner lateral margin of the arms a row of pinnules.

Surface smooth or only finely granular.

Column round, and small, compared with that of other species of the genus, and with the body tapering downward from the base, near which it is composed of thin discs, and farther down of alternately thicker and thinner discs; perforation small and nearly circular, or sub-pentagonal.

Height to the first bifurcation of the rays (medium sized specimen), 0.21 inch; breadth, 0.17 inch; thickness of column at base, 0.08 inch; length of arms, about 0.70 inch.

The above description is made out from the form generally recognized in the west as *H. simplex*, the original type of which was from Cincinnati, Ohio; and it agrees more nearly with the figures and description of that species given in the Palæontology of New York, than any of the known western forms. Consequently I have little doubt in regard to its being that species, although it differs, as will be seen by the foregoing description, and the accompanying figures and diagram, in some of the details from the illustrations and description given in the New York report. For instance, the enlarged diagram showing the anatomy of *H. simplex*, given in the New York Palæontology, vol. 1, pl. 76, fig. 2d, is drawn as if there were no anal pieces whatever (which are, as already stated, now known to exist in all the species of the genus), nor is any truncation of the upper left angle of the second piece in the right posterior lateral ray, or of the right of the left, represented there, for the reception of the first anal piece. The arm-pieces are also represented in that diagram as being decidedly wider than long, and each of equal length at each end; while in our specimens they are as long as wide (excepting in a variety to be mentioned farther on, differing in other respects), and more or less wedge-

shaped, or longer on one side than the other, in all the varieties I have seen. The genus is also described in the New York report as having the arms "not tentaculated." Our specimens of this, and some other species, show that the arms are provided with pinnulæ, or so-called tentacula.

Among the specimens before me from Cincinnati, that I am inclined to refer to this species, there are individuals showing some rather marked varieties in the details of structure, that may possibly hereafter be found to belong to more than one species. In addition to those presenting the characters given above, there is one agreeing in all other respects (see plate 1, fig. 6 *a*, *b*), that has the last piece of each of the radial series a little constricted on each side, and slightly prominent, or protruding at the mesial superior angle; while its lower arm-piece for several ranges up, are proportionally longer than in the specimen described, and somewhat constricted at each alternate suture between them, so that they are joined together by twos in such a manner that each two pieces (that is, the one above and that below each constriction) present together some approach to an hour-glass form. Another specimen (fig. 5 *a*, *b*, of same plate) agreeing exactly in the form and structure of the body, free rays, and arms, up to the third or fourth arm-pieces, with the usual characters of the species; while above this its arms suddenly diminish materially in size, and present the appearance of a new growth of arms that had been broken away during the life of the animal. This may be a normal form or condition of the arms, but I am disposed to view it as the result of some accident, and a subsequent restoration of lost parts, such as not unfrequently occurs in the lower types of animals.

Another individual (fig. 7 *a*, *b*, *c*, of pl. 1), much larger and more robust than the usual size and appearance of the species, but agreeing in all other respects, has the arm-pieces proportionally decidedly shorter than in the smaller average sized specimens, particularly above the middle of the arms, where even at the longer end, the length of these pieces is less than half the breadth. They are all distinctly cuneiform, but they do not have the individual shorter and longer ends regularly alternating on opposite sides of the arms, there being generally two pieces lying together with the longer ends on one side, and then two with them on the other side, the upper one of each pair supporting a pinnule at its longer end, thus giving an alternating arrangement of the pinnules, of one to every third piece along the opposite inner sides of the arms. This is, I believe, the usual arrangement in the smaller individuals; but in those, as already stated, the arm-pieces are proportionally longer and less distinctly wedge-shaped, which causes the pinnules to be less closely arranged.

This large individual agrees almost exactly in size, form and general

appearance with *H. Canadensis*, of Billings (Decade IV, Canadian Org. Remains, p. 48, pl. iv, fig. 5 *a*–5 *d*, which is regarded by some as a variety of *H. simplex*), excepting in its decidedly shorter and cuneiform arm-pieces, there being 12 of these pieces at a point a little above the middle of the arms, in a length of 0.25 inch; while only 5 or 6 pieces can be counted in the same space in Mr. Billings' figures.

This large individual, I suspect, may belong to a distinct species from the others, but I prefer to place it, for the present, as a variety of the same, because in this genus the arm-pieces seem to be subject to more or less variation.

Locality and position: Cincinnati group of the Lower Silurian, Cincinnati, Ohio. Mr. Dyer's and Dr. C. A. Miller's collections. Those in Dr. Miller's collection came from the lower part of the series. The large specimen was sent by Mr. S. A. Miller to the Smithsonian Institution, from a position in the same series, 380 feet above low water mark of the Ohio at Cincinnati; though I am informed by Mr. Miller that the same occurs lower in the series there.

Heterocrinus juvenis, Hall.

Plate 1, figs 3 *a*, *b*, *c*.

Heterocrinus juvenis, Hall, ———; Descriptions of New Species of Palæozoic Crinoids, etc., p. 4, dated Nov., 1866; and (1872) illustrations of a re-issue of same, pl. 1, figs. 9 and 10.

Body very small, less than once and a half as long as wide, with breadth nearly the same above and below, being slightly constricted above at the point where the rays become free; somewhat pentalobate, as seen from below, in consequence of each radial series being convex, and the vertical sutures between them a little excavated. Sub-basal pieces minute or only appearing, externally, as sub-trigonal points at the lower ends of the sutures between the basal pieces, which are comparatively rather large, a little wider than high, with a general pentagonal outline, their lower lateral angles being minutely truncated. First radials in the anterior ray a little longer than wide, and supporting another shorter piece above, that tapers upward and seems to be included as a part of the walls of the body; and upon this rest, in direct succession, three other pieces, that are wider than long, and appear to be free, the third one being axillary, and supporting two arms. Anterior lateral rays with first piece a little wider than long, and supporting in direct succession two other shorter pieces, apparently belonging to the body; while above these there are three still shorter, apparently free pieces,

the last one of which is axillary, and supports two arms. First radial of the left posterior ray, usually a little longer than wide, irregularly hexagonal, or sub-heptagonal in form, and supporting a smaller upward tapering piece above, also apparently belonging to the body series; other parts of this ray unknown. Right posterior ray, with first piece about as long as wide, and pentagonal in form, while it supports, above, a slightly smaller pentagonal body piece, the left superior sloping side of which connects with the first anal, while its right slightly sloping upper side, supports a third smaller radial; which is as far as the parts of this ray can be made out in the specimens studied.

First anal piece (see *a*, of fig. 1 *d*, pl. 1) resting as usual on the left sloping side of the second radial of the right posterior ray, and partly upon a short sloping side of the first radial of the left posterior ray, irregularly pentagonal in form, and bearing above, in direct succession, two other smaller pieces that taper rapidly upward. Surface smooth, or obscurely granulated.

Arms ten, rather short and small; above their origin on the last of the primary radial series, rounded and composed of pieces nearly or quite as long as wide, every fourth or fifth one of which gives off (at least on the interradial side) an armlet or branch about half as large as the main arm above; armlets diverging little from the main arms, and composed of pieces that are longer than wide.

Column proportionally very large, or equaling the diameter of the widest part of the body, sub-pentagonal in form, and composed of moderately thin discs, between each two of which are intercalated, for some distance below the body, five small pieces, ranging exactly on lines with, and corresponding in size and form to, the sub-basal pieces at the connection of the body with the column; farther down these intercalated pieces seem to coalesce and form discs like the others.

Length of body, 0.19 inch; breadth, about 0.17 inch; length of body and free rays to first bifurcation or arm bases, 0.30 inch; length of arms, 0.40 inch; breadth of column, about 0.16 inch.

This species is perhaps most nearly allied, in some respects, to the Cincinnati form usually referred to *H. heterodactylus*, but differs materially in the structure of its arms, which are shorter, and do not regularly divide into equal branches, but merely give off a few lateral armlets, so much smaller than the arms themselves as to present somewhat the character of stout pinnules. The form of its body is also different, not tapering downward to the column, which is likewise very much stouter than that of *H. heterodactylus*. The proportionally very large size of its column, and the smallness of its body and arms, give it a very curious

appearance, so unusual, indeed, that at a first glance the body and arms scarcely attract attention at the end of the column.

I am indebted for the use of the specimens of this species figured to J. Kelley O'Neall, Esq., of Lebanon, Ohio.

Locality and position: Upper part of the Cincinnati group, near Lebanon, Ohio.

Heterocrinus heterodactylus, Hall ?

Plate 1, figs. 1 *a*, *b* (and 2 *a*, *b* ?).

Heterocrinus heterodactylus Hall, 1847; Palæontol., New York, vol. 1, p. 279, pl. 76, figs. 1 *a*, to 1 *o*.

Body small, nearly as wide as long, tapering a little from above. Sub-basal pieces minute, only appearing as little rudimentary sections of the last joint of the column at the lower ends of the sutures between the next range of plates. Basal pieces, composing nearly one-third the height of the body, a little wider than long, with a general pentagonal outline, but having the two inferior lateral angles sometimes very slightly truncated by the minute sub-basals. First and second radial pieces of the right posterior lateral ray, larger than the basals, both pentagonal, and somewhat round on the dorsal side; the first one slightly longer than wide, and the second wider than long, and supporting on its left superior sloping side, the first anal piece, while on its right it bears, in direct succession, four rather decidedly smaller primary radials, that are narrowed and rounded so as to assume the character and appearance of free arm-pieces; on the last of these, the first bifurcation of this ray takes place, and both divisions can be seen to subdivide two or three times again, at intervals of about five of the pieces, which are slender, rounded, and about two and a half times as long as wide. First radial of the right anterior lateral ray, comparatively rather larger, longer than wide, pentagonal in form, rounded on the outer side, and supporting in direct succession above, four smaller, rounded primary radials, all of which, excepting perhaps sometimes the first, presenting the appearance of arm-pieces; on the last of these the first bifurcation of this ray takes place, and of these divisions, the left one can be seen in the specimen to divide again on the fifth piece, and its right subdivision again on the fifth; all the segments or joints of the arms being long and slender like those of the posterior ray. First and second radials of the left posterior ray, comparatively large, the first pentagonal and the second quadrangular, and supporting in direct succession three decidedly smaller, rounded arm-like pieces, on the last of which there *appears* to be a bifurcation;

and this is as far as the structure can be traced in this ray. (Other rays unknown.)

First anal piece of moderate size, and resting like an arm base on the left sloping side of the second radial of the right posterior ray, while its left side connects with the second, and perhaps touches the third radial of the left posterior ray; second anal smaller than the first, tapering upward, and resting upon the first, with its upper end passing obliquely inward between the arm-like radials farther up, where it doubtless joins others forming the base of the ventral prolongation.

Column comparatively rather large and strong, somewhat distinctly pentagonal near the body, with more or less rounded angles, and composed of alternately thicker and thinner pieces; the latter not forming continuous discs, but consisting each of five minute sections, disconnected from each other, and ranged as minute transverse nodes coincident with the five angles of the column, and with the minute pieces at the connection of the latter with the body, that are described above as sub-basals. Farther down the column gradually becomes nearly cylindrical, and the little intercalated pieces more and more developed, until they coalesce, and form complete discs, scarcely distinguishable from the others.

Length of body, 0.17 inch; breadth, about 0.14 inch; length of arms, including the free primary radials, about 0.50 inch; diameter of column near the base, 0.06 inch.

This is the western form that has always been referred to *H. heterodactylus*, of Hall; but as the original typical specimen of that species did not show whether or not its arms bifurcate above the division on the last primary radial, and there seem to be some slight differences in the details of its structure*, its identity with that species can scarcely be regarded as established beyond doubt. The specimen studied, was found by Dr. C. A. Miller, of Cincinnati, in the lower beds of the Cincinnati group at that city. It is represented by our figures 1 *a*, *b*, of plate 1, and shows only the posterior side of the body and column, and the arms of the same side.

I also have before me another specimen belonging to Mr. Dyer's collection, agreeing in size, form and general appearance with that described above, and yet presenting some rather marked differences in the details of its structure; particularly of the parts above the body. It also shows only the posterior side, with the left anterior lateral ray. In the first

* Its left posterior ray bifurcates on the fifth piece, while Prof Hall's figure, 1*d*, shows eight pieces in direct succession in this ray, without any bifurcation, at least that far up.

place, all of its arm-pieces, and free primary radials, are proportionally decidedly shorter, broader, and less rounded; while in its right posterior ray, it has eight pieces below the first bifurcation, instead of only six, the upper five being much shorter than wide. The difference in the length of the arm-pieces, and in the breadth of the arms, give this specimen quite a different appearance, as seen under a magnifier, and it is therefore possible that if we could make a critical comparison of all parts of the two, other corresponding differences might be apparent. If so, and these differences should be thought of sufficient importance to entitle this form to rank as a distinct species or variety, I would propose to designate it by the name *propinquus*, from its close general resemblance to the one I have regarded as *H. heterodactylus*. Our figures 2 *a*, *b*, of plate 1, represent this form.

Locality and position: As already stated, Dr. Miller's specimen of the form first above described, came from the lower part of the Cincinnati group; and the one last above mentioned, was found by Mr. Dyer in the middle part of the same series at Cincinnati, Ohio.

Heterocrinus laxus, Hall.

Pl. 1, figs. 8, *a*, *b*.

Heterocrinus laxus, Hall, 1872; Pl. 1, fig. 15, accompanying a re-issue of a paper of his, date 1866, in which this species is not described.

Body small, somewhat higher than wide, obconoidal, but a little excavated between the radial series of piece, so as to present a sub-pentagonal appearance below. Radial pieces five or six to each ray, not differing materially in form or size, excepting that the first piece in the anterior, right anterior lateral, and left posterior rays, are larger than the others, and longer than wide; in the right posterior, and the left anterior lateral ray, three, and in the others two, of these pieces are included as parts of the walls of the body; the others above these being free, rounded, and separated from those below by a constriction. Anal pieces having the usual arrangement of the genus, that is, the first resting between the sloping, superior lateral sides of the first piece of the left posterior ray, and the second of the right, and supporting two or more smaller pieces in direct succession above.

Arms long, slender, rounded, flexuous, composed of pieces about as long as wide, without being distinctly wedge-formed, though about every fourth one is somewhat larger than the others, and gives off a stout armlet nearly half as thick as the main arms; armlets rounded, alternately arranged on each side of the main arms, and composed of joints that

appear to be nearly twice as long as wide. Surface nearly smooth, or somewhat granular.

Height of body, 0.28 inch; breadth, 0.15 inch; breadth of base, 0.10 inch; thickness of arms at their bases, 0.05 inch; length unknown.

The above description, and our figure and diagram, were made out from the original typical specimen, loaned for that purpose by Mr. Dyer. It does not retain the column, but from the pentagonal outline of the base, it is very probable that the column is distinctly pentagonal at its upper end; and it must also be comparatively rather slender.

This species seems to be most nearly related to the form I have referred doubtfully to *H. heterodactylus;* but it differs in having its body proportionally longer, and more angular, its basal and arm-pieces shorter; while the armlets, or lateral divisions of its arms, are given off at shorter intervals, and its arms proportionally stouter.

Locality and position: Cincinnati group of the Lower Silurian; Cincinnati, Ohio. Mr. Dyer's collection.

Heterocrinus [Iocrinus] subcrassus, M. and W.

Plate 1, figs. 9 *a*, *b*.

Heterocrinus subcrassus, Meek and Worthen, 1865; Proceed. Acad. Nat. Sci., Philad., p. 148; Illinois Geological Report, Vol. III., p. 325, pl. 4, fig. 5 *a*, *b*, *c*, 1868.
Heterocrinus? (*Iocrinus*) *polyxo*, Hall, ——; Descr. New Species *Crinoidea* and other fossils, page 5, dated Nov., 1866; also (1872) in re-issue of same, pl. 1, figs. 1 to 4.
Heterocrinus (*Iocrinus*) *subcrassus*, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 310.

Body presenting the form of a short truncated and inverted pentagonal pyramid, with the five sides deeply concave, excepting at the top, where the breadth is nearly double the height; thence tapering abruptly to the stout column below. Sub-basal pieces undeveloped. Basal pieces, of moderate size, about twice as wide as high, pentagonal in form, the superior sloping margins and lower side being comparatively long, and the lateral very short; all deeply concave up the middle of the outer surface, and very prominent on each side. First radial pieces comparatively large and strong, wider than high, pentagonal in form, and truncated nearly their entire breadth above, for the reception of the succeeding pieces; each very profoundly excavated on their external surface, at the inferior lateral angles, so as to leave all the central region standing out in the form of a very prominent vertical ridge, coincident with that formed by the prominent lateral margins of the basals; while a some-

what similar, but less prominent ridge, extends horizontally across the upper margins on each side, so as to connect with each other on each two contiguous plates.

Right posterior ray, with the second piece a little larger than those of the other rays, twice as wide as long, irregularly quadrangular, or sub-pentagonal in form, with the upper two sides sloping so as to give it the appearance of an axillary piece, but the left, shorter sloping side, merely supports the first anal piece; while from the right continue the succeeding true radials, of which there are three short, smaller pieces in direct succession, the third one being axillary and supporting the first free divisions of the arms. Other rays, bifurcating on the third, fourth or fifth of the free radials, which are smaller than the first, scarcely half as long as wide, and rounded on the outer side. Arms rather long, gradually and regularly tapering; bifurcating three to four times or oftener, above the first division of the rays on the last primary radial. Arm-pieces, like the free radials, all projecting at the upper edge, so as to present a kind of upward imbricating, or roughened appearance.

Anal series, consisting of a direct vertical range of pieces, that are very convex and rounded on the outer side, and rise from the left sloping side of the second radial of the right posterior lateral ray, so as to present much the appearance of an arm, or branch of this ray, but connecting on each side with others forming the lower part of the ventral prolongation. Surface smooth.

Column stout, distinctly pentagonal, the angles coinciding with those of the body; composed near the body, of alternately thicker and thinner pieces.

Height of body, 0.18 inch; breadth of same at top, 0.31 inch; thickness of column at its connection with the base, 0.17 inch; length of arms above the first divisions of the rays, about 1.60 inches; thickness of same just above the last primary radial, 0.08 inch.

This species is most nearly related to *H. crassus*, Meek and Worthen, from the same horizon in Illinois; but differs in being smaller, less robust, and particularly in the slenderness and peculiar roughened appearance of its arms. This latter character is produced by the slight projection of the arm and free radial pieces, on their upper margins, beyond the lower margin of each succeeding piece above.

In the right posterior ray not only the first and second radial pieces are included as a part of the walls of the body, but two, if not all three of the smaller succeeding primary radials, seem also to connect laterally with the pieces forming the lower part of the ventral prolongation.

In first describing this species, Mr. Worthen and the writer mentioned the anal series doubtfully, as a branch of one of the rays, though we at the same time explained, in a foot note, in describing the closely allied species, *H. crassus*, that these may be properly anal pieces, and not an arm or division of this ray. In re-describing these forms in the fourth volume of the Illinois Report, however, we distinctly pointed out that these pieces belong to the anal series.

In describing this species under the name *Heterocrinus? (Iocrinus) polyxo*, Prof. Hall evidently confounds these anal plates with a division of the arms or rays, as he distinctly states that "no anal plates have yet been observed in any of the individuals examined;" while he farther on adds that "the first division of the arms takes place on the second radial plate in one ray." He placed the species doubtfully in *Heterocrinus*, under a sub-genus, *Iocrinus*. The differences in its general physiognomy, and in the number and proportional size and form of the primary radials included as a part of the walls of the body, may render this distinction desirable.

Locality and position: Upper part of the Cincinnati group of the Lower Silurian, at Cincinnati, Ohio. Mr. J. Kelley O'Neall's collection.

Genus ANOMALOCRINUS, Meek and Worthen, 1868.

(Illinois Geol. Report, Vol. III., p. 327.)

Anomalocrinus incurvus, M. and W.

Pl. 2, figs. 6 *a, b, c, d, e, f.*

Heterocrinus? (Anomalocrinus) incurvus, Meek and Worthen, 1865; Proceed. Acad N. S., Philad., p. 148, Aug., 1865.

Hybocrinus? (Anomalocrinus) incurvus, Meek and Worthen, 1868; Illinois Geological Report, Vol. III., p. 327, pl. 4, fig. 3 *a, b.*

Ataxocrinus caponifornis, Lyon, 1869; Trans. Am. Philos. Soc., Vol. XIII., p. 464, pl. xxvii., fig. O, O 1, O 2, and O 3.

Body depressed sub-globose, expanding very rapidly from the base to the summit of the first and second radials, where it is about twice as wide as high. Basal pieces wider than long, and pentagonal in form, with the superior sloping sides and basal margin longer than the lateral.* Three of the rays with the first radial pieces from three to five times as large as the basal pieces, wider than long, and, like the second pieces in

* Between two of those on the anal side, a sixth smaller, probably abnormal, quadrangular piece occurs in the specimen studied.

the other rays, all very strongly incurved above, between the free radials. Two of these pieces present an irregular octagonal general outline on the outer side, and the third larger one in the left posterior ray, a general ten or eleven-sided outline; while in one of the specimens studied, this piece is abnormally split in two, by a vertical suture passing up the middle, over the intercalated abnormal sixth basal piece; and in another specimen, not only this, but the second piece of the next ray to the left is also split in two. First radials in the other two rays, smaller than those of the three rays described, wider than long, pentagonal in form, and each supporting, in direct succession above, a wider second radial of about the same length, that is also included as a part of the walls of the body, and shows a general hexagonal outline; these latter two second radials, and the first three of the other rays, each provided with a comparatively very small, nearly flat, outward sloping facet above, for the reception of the much smaller free radials, which are comparatively very narrow, but generally as wide as long, or a little wider, distinctly rounded or arm-like, and number in direct succession, in the right posterior ray, four, in the left, one, in the right anterior-lateral, two, in the left, three, and in the anterior ray, two. Surface finely, or more or less coarsely granular, with sutures sometimes slightly furrowed.

Arms distinctly diverging at their origin on the last of the small free primary radials, long, slender, and very irregularly bifurcating several times above; the divisions being often of unequal size, rounded and composed each of a single range of pieces that are as long as wide, or sometimes longer, more or less constricted around the middle, and bear stout pinnules.

Column stout, round, composed of very thin discs or segments, and, near the base, provided with a large pentagonal opening; segments having the appearance, when moistened and examined by a magnifier, of each being composed of numerous little anchylosed spicula of irregular size and form.*

Height of body, on the posterior side, 0 67 inch, and on the anterior, 0.43 inch; greatest breadth, 0.92 inch; thickness of column at its connection with the body, 0.34 inch.

Although the specimen from which the original description of *Ataxocrinus caponifornis* of Lyon was drawn up, was larger than the type of

* A root in Mr. Dyer's collection, probably of this species, consists of a solid expansion near an inch in diameter, with irregular margins. It has a short piece of the column attached, which rises abruptly from the expansion, and is composed of very thin anchylosed segments, showing this appearance of being each made up of numerous little pieces, very clearly seen, when examined under a glass. See pl. B, fig. 6 *d*.

Anomalocrinus incurvus, M. and W., I cannot doubt that the two proposed species are really the same crinoid. The specimens here under consideration agree well in size and other characters with that studied by Mr. Lyon, excepting in the abnormal presence of a sixth basal piece in one, and the division, vertically, of some of the large primary radials. As these characters, however, are not constant in the specimens, of course they cannot be of specific importance. The small intercalated sixth basal piece has, so far as I know, only been seen in the single specimen figured, there being no traces of it in others agreeing in all other respects; while still others, that agree equally well in all other characters, have none of the primary radials divided into two by a vertical suture.

This division of some of the large primary radial pieces composing the body, is a very peculiar feature. These pieces are divided by a central suture, terminating above directly under the sinus for the reception of the first of the small free radials. Sometimes this suture passes directly from the sinus above to the middle of the lower margin of the piece, and in other examples, very obliquely. I have never seen more than two pieces in any one specimen so divided, and it is probable that a majority of specimens have none of these pieces split in this way; which was the case with Mr. Lyon's typical example, as well as with that studied by Mr. Worthen and the writer.

In first describing the species founded upon the last mentioned specimen, we place it doubtfully as a *Heterocrinus*, but stated that it differed from the typical form of that group, to such an extent, that, if we were sure the characters presented in the specimen were normal, we would be inclined to view it as the type of a new genus. At the same time we proposed to range it, provisionally, under a sub-generic name, *Anomalocrinus*.

In re-describing it in the Illinois Report, we retained the name *Anomalocrinus*, but placed it provisionally as a sub-genus under *Hybocrinus* of Billings. It seems to me now, after examining several fine specimens, to differ too much from both of the above named genera, as well as from all of the other established groups, to be ranged as a sub-genus under any of them. Mr. Lyon made it the type of a distinct genus *Ataxocrinus* in 1869, and I would willingly retain his name, but for the fact that our name *Anomalocrinus* was published in 1865, and again in 1868; consequently the law of priority requires that it should be adopted.

None of the specimens I have yet seen are in a condition to give any clue to the nature of the vault; but that figured by Mr. Lyon shows that it is not elevated or produced, as in *Heterocrinus*, but scarcely rises above the summit of the body; while in the structure and arrangement

of its body-plates, it differs, as stated above, from that genus, though related to it in some points of structure.

Locality and position: Upper part of the Cincinnati group, at Cincinnati, Ohio. For the use of the fine specimen figured, we are under obligations to Dr. C. A. Miller, of Cincinnati. Other good examples were also loaned for study by Mr. Dyer, of the same city.

Genus POTERIOCRINITES, Miller, 1821.

(Nat. Hist. *Crinoidea*, p. 68.)

Sub-genus DENDROCRINUS, Hall, 1852.

Poteriocrinites (Dendrocrinus) Cincinnatiensis, Meek.

Plate 3 *bis*, figs. 5 *a*, *b*.

Poteriocrinites (*Dendrocrinus*) *Cincinnatiensis*, Meek, 1872; Proceed. Acad. Nat. Science, Philad., Feb'y, p. 312.

Body of about medium size, obconic or tapering to the column from above, nearly or quite as wide at the top of the first radials as the height to the same. Base forming a rather rapidly expanding cup, nearly twice as wide as high. Basal pieces of moderate size, wider than high, pentagonal in form, and each provided with a minute notch at the middle of the under side, corresponding to a furrow extending up each side of the column. Sub-radial pieces about twice as large as the basals, as wide as long, or slightly wider, all hexagonal, excepting the one on the anal side, which is heptagonal, and a little larger than the others. First radial piece in the ray on the right of the anal series a little smaller than the sub-radials, and pentagonal in form; supporting on its upper truncated edge a rather shorter piece corresponding to the slightly larger first radials in the other rays, and like the latter, rounded on the outer side, with a pentagonal outline, and a somewhat narrowed facet above, for the reception of the first free radials. Succeeding or free radials, distinctly narrower than those forming a part of the walls of the body, rounded on the dorsal side, and, in the two posterior-lateral rays, all shorter than wide; while the fifth one in each of these rays is an axillary piece, supporting two arms. (Other rays unknown.)

First anal piece nearly as large as the sub-radial upon the upper side of which it rests; connecting on the left with the first radial piece, and on the right with the first and second radials; while it supports others above, forming the base of the ventral extension, which is composed of small pieces strengthened by radiating ribs.

Arms of the two posterior rays rounded, composed of pieces slightly

wider than long, and a little projecting at their upper margins; each bifurcating at least twice (and perhaps oftener) at unequal distances above their origin on the last primary radials.

Column of only moderate size, for an inch or so below the base, where it is very distinctly pentagonal, the angles being a little rounded, with a rather deep furrow between, on each side; composed of short pieces, which near the base seem to alternate with much thinner ones.

Length of body to the top of first radials, 0.25 inch; breadth of same, 0.23 inch; thickness of column at its junction with the body, 0.07 inch breadth of free rays below the first bifurcation, 0.06 inch.

So far as the specimens afford the means of making a comparison, this species would seem to be nearly related to *Poteriocrinus gracilis* of Hall, described in the first volume of the Palæontology of New York, p. 84. His diagram and figure, however, do not show whether that species has two of the primary radials of the right posterior ray included as a part of the walls of the body, as in *Dendrocrinus*, or whether it has more properly the structure of *Homocrinus*. He represents the first anal piece, however, proportionally much smaller than it is in our crinoid, while to the right of, and partly beneath, the anal piece, he shows in his diagram a small piece, that *seems* to occupy the position and relations to other parts of the sub-anal in true typical *Poteriocrinites*.* His specimen had only a segment or two of the column attached, but an end view of it in his diagram represents it as being *round*, while in the form under consideration it is very distinctly pentagonal. As he does not *say* that it differs in the form of the column from his *P. alternatus* (which has a decidedly round column) in pointing out the distinctions between the two, I also infer that it is round in both. In addition to this, *Poteriocrinites gracilis* of Hall is stated by him to be found only at the base of the Trenton limestone; while our crinoid is only known to occur in the middle or upper part of the Cincinnati group. From these facts, and the usual

* Prof. Hall also ranges it under *Poteriocrinus*, in his corrected list of the New York fossils, published in 1859, after he had proposed the genera *Homocrinus* and *Dendrocrinus*, and included this form in the former group in 1852; from which we may infer that his type has more recently been found to possess the structure of typical *Poteriocrinites*. In that case, it would, of course, differ *specifically* from our crinoid: but if either a *Poteriocrinites* proper, or a *Dendrocrinus* (if we view the latter as only a subgenus of *Poteriocrinites*, as Prof. Hall has since done in describing other species), then the name *P. gracilis* could not stand for the New York fossil, because Prof. McCoy had used that specific name for a species of this genus from the Carboniferous rocks, in 1844. For this reason, D'Orbigny proposed the name *P. sub-gracilis* for the New York species, which will have to be retained if it belongs to any mere section of that genus.

very restricted vertical range of the species of *Crinoidea*, I infer that our Cincinnati form is specifically distinct from the New York species.

Locality and position: Cincinnati, Ohio, in the upper part of the Cincinnati group of the Lower Silurian. Mr. C. B. Dyer's collection.

Poteriocrinus (Dendrocrinus) polydactylus, Shumard (sp).

Plate 3 *bis*, fig. 9.

Homocrinus polydactylus, Shumard, 1867; Trans. Acad., St. Louis, vol. 1, p. 78, pl. 1, fig. 6.

An examination of good specimens of this species shows that it has the structure of the body seen in *Dendrocrinus*, and that it is related to *D. Jewettii*, of Billings, more nearly than to any of the other species known to the writer. Our fig. 9 of plate 3 bis, represents the posterior side of a good specimen of this species.

This is a rather common species in the upper part of the Cincinnati group at Richmond, Indiana.

Poteriocrinites (Dendrocrinus) posticus, Hall.

Plate 3 *bis*, figs. 4 *a*, *b*, *c*.

Poteriocrinus posticus, Hall, 1872; Plate 1, figs. 5 and 6, illustrating second edition of a paper bearing date of Oct., 1871, in which the species is not described.

Body small, obconic, wider above than the height to the top of the first radials, from which point it tapers rather abruptly to the column below; basal pieces pentagonal, forming about one-fourth the height to the top of the first radials, and all a little wider than high; sub-radials two to three times as large as the basals, about as wide as long, all hexagonal, excepting one on the anal side, which is heptagonal, and somewhat larger than the others; first radials smaller than the sub-radials, with which they regularly alternate, and having a pentagonal general form, but sometimes with the superior lateral angles a little truncated, each, excepting in the right posterior ray, supporting, in direct succession, five other rather small radials, which are rounded so as to present an arm-like appearance, the last one bearing the first divisions of each ray; right posterior ray having six of these pieces above the first, the second piece being, as usual in the group, larger than those above, and corresponding to the first piece in the other rays, in being included as a part

of the walls of the body: one or two of the pieces farther up in this ray, as well as some of those of the other rays, are likewise included as parts of the walls of the ventral extension.

First anal piece nearly or quite as large as the largest sub-radial upon which it rests, hexagonal in form, and connecting on the left with the first radial of that ray, and on the right with the first and second radial of the right posterior ray; while it supports, in direct succession, two or three rows of small pieces above, that compose the posterior basal part of the ventral extension, and in part connect with the radial series on each side. A few small pieces are also seen between the other rays, and connecting with some of the lower radials on each side, so as to present the appearance of interradials, but they more properly belong to the ventral part.

Ventral extension long, apparently cylindrical, and, as usual, composed of about eight vertical rows of alternating hexagonal pieces, with a small ridge extending up the middle of each row, and numerous smaller transverse ridges between.

Arms rounded, and, as in other species of the group, composed each of a single series of pieces nearly as long as wide; bifurcating once or oftener, above their origin on the last free radial pieces, the divisions being usually somewhat unequal in size.

Column unknown; surface nearly smooth, or finely granular.

Height of body to the top of the first radial pieces, 0.18 inch; breadth at the top of same, 0.24 inch; breadth of base at its connection with the column, 0.09 inch.

The specimens of this species from which the above description, and our figures on plate 3 *bis*, were prepared, are those upon which the species was originally founded. They do not retain any part of the column, but from the rounded character of the base, it is probable that the column is round.

It appears to be related to the last, but has decidedly shorter basal pieces, which show no traces of the indentations below, corresponding to the concave sides of the sharply pentagonal column, so characteristic of that species; while its arms are stouter, and composed of pieces that are not a little projecting at their upper and lower margins, as in that species. It seems to be even more nearly related to *P. gracilis*, Hall (not McCoy), than the last is, but has much shorter basal pieces, and a direct comparison of good specimens would doubtless show other well defined differences. It certainly presents one peculiarity, not yet *known* to occur in any other species of the group, unless it may be in the first of the

following species. That is, in having some of the primary radial pieces, above those forming the body, included as a part of the walls of the ventral extension. From that species, however, it differs so widely in nearly all other respects as to render a comparison unnecessary.

Locality and position: Cincinnati group of the Lower Silurian, at Cincinnati, Ohio. Mr. Dyer's collection.

Poteriocrinites (Dendrocrinus) Dyeri, Meek.

Plate 3 *bis*, figs. 3 *a*, *b*.

Poteriocrinites (*Dendrocrinus*) *Dyeri*, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., Feb'y, p. 314.

Body small, obconic, or tapering regularly to the column from above. Basal pieces longer than wide, the greatest breadth being across between the superior lateral angles; all pentagonal. Sub-radial pieces a little larger than the basals, longer than wide, and, excepting the one on the anal side (which is largest and heptagonal), all hexagonal. First radials of about the size of the sub-radials, but proportionally broader, being a little wider than long, with a general pentagonal outline, though all excepting the one on the right of the anal series, have the superior lateral angles a little truncated; while the second piece in that ray, which, as is usual in the group, corresponds to the first in the other rays, also has these angles truncated. Succeeding radials in all the rays much narrower, about as long as wide, or slightly longer, and numbering from five to six or seven pieces below the first bifurcation. Arms remarkably long and slender, laterally compressed, more or less angular on the dorsal side, and giving off alternately on opposite sides, at distant intervals above the first bifurcation of each ray, from three to four or more scarcely diverging divisions, that are slightly more slender than the main arms, from which they spring, and sometimes themselves bifurcating once or twice, and composed of pieces about as long as wide.

First anal pieces nearly as large as one of the smaller sub-radials, resting on the superior truncated edge of the largest heptagonal sub-radial, between the first radial on the left, and the first and second on the right; while it supports others above, that form the base of the ventral extension. Interradial spaces with the lowest piece of the ventral part resting between the truncated superior-lateral angles of the first primary radials, so as to appear like minute interradials. Surface without costæ or sculpturing of any kind.

Ventral extension very long, or nearly or quite equaling the length of

the arms, and as wide as the body below; composed of the usual small hexagonal plates, apparently without costæ, and separated by punctured sutures. Column slender, slightly tapering downward just below the base, near which it is more or less pentagonal, and composed of short alternately thicker, and exceedingly thin, segments. Farther down, it becomes nearly or quite cylindrical, and composed of more uniform, very short pieces, with a very small, nearly or quite round perforation.

Length of body from the lower end of base to the top of first primary radials, 0.24 inch; breadth of do., at top, 0.16 inch; length of rays from top of body to first bifurcation, 0.20 inch; length of arms above this bifurcation, 2.30 inches; diameter of column, 0.04 to 0.05 inch.

This delicate little species seems to agree exactly in structure, as well as in physiognomy, with the genus *Dendrocrinus*, excepting that it *appears* to have the small pieces forming the lower part of its ventral extension above the first anal piece, and those seen in the interradial spaces above the large first radials that form a part of the walls of the body, connecting laterally with the succeeding smaller radials nearly up to the first bifurcation. This arrangement, if it really exists, would make these smaller primary radials above the body proper, as it were, a part of the walls of the ventral extension, so that the rays would only become free near the first bifurcation. The specimens seen are not quite in a condition to remove all doubts on this point, but in some conditions these little pieces between the rays give that part of the fossil somewhat the appearance of a *Glyptocrinus*. The presence of well developed subradials, and a long ventral extension of the body, exclude it, however, at once, from that genus (to say nothing of other differences), as well as from *Mariacrinus*, from which latter it also differs materially in the structure of its arms, and in other important characters.

In general appearance, it seems to resemble most nearly *Dendrocrinus acutidactylus*, and *D. gregarius* of Billings. It differs from the first, however, in having a more slender body, with proportionally longer arms, much less diverging at the bifurcations, as well as in having the two branches at each division unequal. From the latter species, it also differs in the nature of its arms, as well as in having its column composed of very short pieces, not presenting a bead-like appearance.

Locality and position: Cincinnati group of the Lower Silurian, at Cincinnati, Ohio, where it occurs at the horizon of 100 feet below the tops of the hills. The Survey is under obligations to Mr. C. B. Dyer, of Cincinnati, for the use of the only known specimens of this species.

Poteriocrinites (Dendrocrinus) caduceus, Hall.

Plate 3 *bis.*, fig. 1 *a*, *b*, *c*, *d*.

Poteriocrinus (*Dendrocrinus*) *caduceus*, Hall, ———; Descrip. New Sp. Crinoidea, etc., p. 3, dated Nov., 1866; also (1872) illustrations of new issue of same, pl. 1, figs. 7 and 8.

Body obconic being a little higher than the breadth at the top of the first radial pieces, which are more or less prominent and rounded on the outer side above, owing to the excavation of the interradial spaces; tapering regularly from above to the rather small column. Base wider than high, and forming nearly one-third the height of the body; basal pieces longer than wide, pentagonal, with the superior sloping sides each about equaling the length of the lower side, and shorter than the lateral margins. Sub-radial pieces three or four times as large as the basals, longer than wide, and all hexagonal, excepting one on the anal side, which is heptagonal. First radials somewhat shorter than the sub-radials, but of near the same breadth, pentagonal in form, and all (excepting that of the right posterior ray) more or less deeply excavated above for the articulation of the first of the succeeding free radials; first and second pieces of the right posterior ray smaller than the first in the other rays, a little wider than long, the upper one, which corresponds to the first piece in each of the other rays, being quadrangular, with the upper side wider, and generally merely truncated above for the reception of the first of the smaller fine radial.

Free radial pieces decidedly smaller than those included as a part of the body, being much narrower than the latter, and scarcely more than half as long as wide; all rounded on the dorsal side. First bifurcations of the rays at somewhat variable distances above the body; generally on the sixth free piece, but sometimes farther up, or on the seventh, or even on the eleventh, in the left posterior ray.

Arms bifurcating several times above the first division on the last free primary radials, the divisions being sometimes unequal in size, and becoming much attenuated, the smaller divisions being composed of proportionally longer joints.

First anal piece shorter than the sub-radial on which it rests, but of about the same breadth, hexagonal in form, and supporting a direct series of hexagonal pieces above, that connect with others on each side, forming the lower part of the ventral prolongation.

Surface of body nearly smooth, excepting broad, very obscure ridges, radiating from the central regions to the sides of each plate, to meet

others on the adjacent plates; thus leaving a vertically elongated, rhombic, shallow excavation between, and partly upon, the lateral margins of each two contiguous sub-radials, across each of which excavations three smaller, very faintly defined ridges or costæ may be seen passing horizontally near the edges of these plates. Similar, but proportionally smaller excavations (without the transverse ridges), are also seen between the basal pieces; and a trigonal one at the meeting of the mesial superior angle of each sub-radial and the inferior lateral angles of the first radials.

Column comparatively small, sub-pentagonal or nearly round; and near the base composed of alternately thicker and thinner segments, that show indications of division into five parts by longitudinal sutures.

Length of body to top of radials, 0.35 inch; breadth at same point, 0.34 inch; length of arms from the first divisions of the rays to the extreme ends of some of their smallest sub-divisions, sometimes 2.40 inches or more.

Of this fine species, I have for study nine examples of the body, with more or less of the arms and column attached to each, all from the same locality and position as the original typical specimen. These are generally in a good state of preservation, and, taken together, give a fine opportunity to work out nearly the entire structure. They show that its arms each bifurcate several times, the divisions (above the first bifurcation) being generally unequal, the smaller one becoming very attenuated, but usually, like the larger, bifurcating two or three times. Prof. Hall describes the arm-pieces as having their "upper lateral margins somewhat projecting for the attachment of tentacula." The specimens under consideration show this slight projection of the superior lateral margins of the arm-pieces; but I have been unable to see any traces of tentacula (pinnulæ) in connection or association with any of them, though detached pieces of the very attenuated sub-divisions of the arms themselves, as seen lying in the matrix, might be readily mistaken for such. His statement that the arms or rays bifurcate first on the sixth piece above the first radial plate, although agreeing with the general structure of our specimens, is not strictly correct with regard to all of the rays of all the specimens, the left posterior lateral ray in one case showing, as stated in the description, seven of these pieces, and another eleven, below the first division.

None of the specimens examined show the ventral prolongation, but it is doubtless much produced as in other species of the group.

Locality and position: Upper part of Cincinnati group, of the Lower Silurian, near Lebanon, Ohio. For the use of the specimens from which our description and figures were made out, I am under obligations to J. Kelley O'Neall, Esq., of Lebanon, Ohio.

Poteriocrinites (Dendrocrinus) Casei, Meek.

Plate 3 *bis.*, fig. 2 *a*, *b*, *c*.

A Pentacrinite, Christy, 1848; Letters on Geology, plate II. (without a description or specific name.)

Dendrocrinus Casei, Meek, 1871; Am. Jour. Sci. and Arts, Vol. II. (3d ser.), p. 295; issued Sept. 29th, for October, 1871.

Column very distinctly pentagonal, the angles at the connection with the body being continuous, with strong ridges passing up the sutures between the basal pieces and to the middle of the sub-radials. Body having the form of an inverted pentagonal pyramid, a little wider above than its height. Base wider than high, strongly pentagonal, being deeply excavated up the middle of each piece, and very prominent at the lateral sutures; basal pieces wider than high, pentagonal in form, with the mesial angle above salient, and the superior lateral sloping sides much longer than the lateral margins. Sub-radial pieces of moderate size, four hexagonal and one heptagonal, all very convex in the middle, from which point they each send one strongly elevated ridge to each side to meet others on each of the surrounding plates, and one to the mesial angle below to another coming up the sutures between the basals; while on each side of these ridges, excepting sometimes those passing to the first radial pieces above, there is usually a smaller, less elevated parallel ridge; the surface of the body being divided by these ridges into profoundly excavated triangular spaces, in the middle of which the corners of the body-plates meet. First radial pieces, excepting one on the anal side, larger than the sub-radials, about as wide as high, with a general pentagonal outline, the upper side being longest and deeply excavated for the reception of the comparatively narrow free radials; one on the right of the anal series pentagonal, and supporting another radial above, that is included as a part of the walls of the body, and corresponding to the first piece in the other rays; all the first radials in four of the rays, and the second in the other, convex in the middle, and sending a strong ridge to each of the contiguous body-plates below, while six or eight much smaller ridges pass horizontally across from one to another of each two contiguous plates of this range. Succeeding radials free, much narrower and assuming the character of arm-pieces; in the posterior rays the fifth piece above the body being axillary and supporting each two arms, which are long, rounded, and seen in one of the specimens to bifurcate at least twice above, where they become quite slender, and are composed of pieces that are longer than wide; anterior and anterior lateral rays, bifurcating

first on the sixth or seventh piece, which is as far as they can be traced in the specimen studied.

Anal series with the first piece resting directly upon the upper truncated side of the heptagonal posterior sub-radial, hexagonal in form, and bearing in direct succession above a series of hexagonal pieces gradually diminishing in size; while alternating with these similar small hexagonal pieces can be seen on each side of the mesial series, for some distance above the body between the free rays, and connecting with those of the ventral part.

Ventral prolongation of the body more than five times as long as the body itself, and, as seen flattened, of greater breadth than the same; apparently equaling the entire length of the arms; as usual, composed of numerous small hexagonal, alternately interlocking pieces, of equal size, that are strengthened by little, transverse, or slightly oblique costæ, so arranged as to present an ascending zig-zag appearance.

Height of body to the top of the first radials, 0.39 inch; greatest breadth at top of same, 0.32 inch; length of incomplete ventral prolongation, 1.95 inches; breadth of same as flattened near upper end, 0.65 inch; breadth of free rays below the first bifurcation, 0.12 inch.

Although differing considerably in its physiognomy from the typical species on which the genus or sub-genus *Dendrocrinus* was founded, this crinoid agrees well in its fundamental points of structure with the same, and evidently belongs to the same group. In general appearance its body resembles that of *Palæocrinus angulatus* of Billings, but it differs in having the costæ of its body-plates, in part, with each a smaller one on each side; and its column is very much more distinctly pentagonal. Of course it also differs in the generic character of having its ventral portion prolonged so as nearly or quite to equal the length of its arms, instead of scarcely rising above the horizon of the arm-bases, as in *Palæocrinus*.*

Since seeing a plaster cast (belonging to Mr. U. P. James, of Cincinnati) of the crinoid figured by Mr. Christy in the paper cited at the head of this description, under the name *Pentacrinites*, I have no doubt that it is the same species here described; Mr. Christy's figure being enlarged and inaccurate in some of the details of structure and ornamentation.

The *Dendrocrinus* group agrees so nearly with *Poteriocrinites* in structure, that it ought probably not to be regarded as more than a sub-genus under the same.

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* Now, since the nature of the vault of *Cyathocrinites* is known (see Proceed. Acad. Nat. Sci., Philad., Dec., 1868, pp. 324 and 336), it seems to me that *Palæocrinus* can scarcely be retained as distinct from that genus.

The specific name of the form here described was given in honor of L. B. Case, Esq., of Richmond, Indiana, to whom I am indebted for the use of the first specimen of the species I have seen. I am also under obligations to Mr. C. B. Dyer, of Cincinnati, for the loan of two smaller specimens, one of which (see fig. 3 *c*) shows the anal side, and more of the arms, than the larger one belonging to Mr. Case.

Locality and position: Mr. Case's specimen was found by him at Richmond, Indiana, in the upper part of the Cincinnati group of the Lower Silurian; and those belonging to Mr. Dyer came from the same horizon, between Cincinnati and Oxford, Ohio.

Genus GLYPTOCRINUS, Hall, 1847.

(Palæontology N. Y., Vol. 1, p. 281.)

Glyptocrinus decadactylus,* Hall.

Plate 2, figs. 5 *a*, *b*.

Fossil Encrinite, Anthony, 1839; Am. Jour. Sci. and Arts, Vol. XXXV., p. 405, with a wood cut.

Glyptocrinus decadactylus, Hall, 1847; Palæont. N. Y., Vol. 1, p. 281, pl. LXXVII., fig. 1, *a-f;* and pl. LXXVIII., fig. 1, *a-u*.

Body obconoidal, with interradial and axillary areas a little flattened, so as to present a slightly pentagonal outline, as seen from below; somewhat higher than wide, and tapering to the column below. Sub-basal pieces undeveloped. Basal pieces small, pentagonal in form, wider at the top than high. First radial pieces larger than the basals, as wide as long, and heptagonal in form. Second radials a little smaller than the first, and hexagonal or heptagonal in outline; third radials of the same size as the second, heptagonal in outline, and each supporting on its upper sloping sides the secondary radials, of which there are two in direct succession in each division, that are nearly as large as the third primary radials; while on the second of these, another bifurcation takes place, giving origin to two series of brachial pieces, the first two or three of which are included as a part of the walls of the body, so as to present the appearance of tertiary radials, but there are no farther bifurcations, the free arms being directly continued from the last included brachial pieces, thus making four arms to each ray, or twenty to the entire series.

Interradial series, consisting of one piece in the first range, resting between the superior sloping sides of the first primary radials; over each

* It was an unfortunate misnomer to call this species *decadactylus*, as it has 20, instead of only 10 fingers, or arms, as they are now called.

of these, two occur in the second range, three in the third, and two or three in the fourth; while above the latter ten or twelve smaller pieces may usually be counted in each area of adult specimens. Anal area occupied by about the same number of pieces as the interradial, but with a somewhat different arrangement, there being above the first piece three in each range, those of the middle series resting each directly upon the upper truncated side of the next below, all the way up. Axillary areas each occupied by about three small pieces; while each interbrachial area is also occupied by two or more very small pieces.

Arms rising vertically from the last attached brachial pieces; long, slender, simple, rounded on the outer side, and composed each of a single series of very short wedge-formed pieces, each of which supports at its larger end a pinnule; pinnules alternately and very closely arranged along the inner lateral margins of the arms; very slender, and composed of joints three or four times as long as wide.

Surface elegantly ornamented, with radiating costæ, of which those passing up the middle of the primary and secondary radials to the arm-bases, are a little larger and more prominent than the others, so as to form continuous narrow ridges; while the others radiate from the center of each of the body-plates to each of its sides, where they connect with those on the contiguous plates, so as to divide the whole surface into numerous triangular impressed areas.* Vault depressed to the horizon of arm bases, and composed of numerous, very small, generally hexagonal pieces, that are nearly flat, or sometimes rise into little node-like prominences in the middle.

Column of moderate size, and, near the base, round, and composed of alternately thicker and thinner pieces, the former of which are also a little wider, so as to project somewhat beyond the others; perforation distinctly pentagonal.

Height of the body of a very large, fine specimen, 1.30 inches; breadth of same, about 0.95 inch; thickness of arms at their bases, 0.09 inch.

This is one of the most common and beautiful crinoids of the Cincinnati rocks, and can be readily distinguished from all the other known species by the form and structure of its body. In its ornamentation it resembles *G. Dyeri*, but it differs materially from that species, not only in its more elongated obconical form, but in only having two, instead of nine or ten pieces in each division of the rays, between the first bifurcation and the arm-bases, as well as in other details of structure. In gen-

* In well preserved specimens, the costæ sometimes become suddenly attenuated before meeting at the center of the plates.

eral form it is more like *G. O'Nealli*, from which it may be at once distinguished, by its less deeply excavated interradial and interbrachial areas, which are also occupied by larger and much less numerous pieces. It also presents the important difference of having its secondary radials (and even some of the lower brachial pieces) included as a part of the walls of the body, instead of becoming free between the first division and the arm-bases; while the distinct radiating costæ of its body-plates is another strongly marked distinction.

Among all of the numerous fine specimens of this species I have seen from Cincinnati, I have not observed the undulating character of the sutures between the body-plates, represented by figure 1 *e*, pl. 77, of Prof. Hall's illustrations in volume 1 of the New York Palæontology.

Locality and position: Middle and upper part of Cincinnati group of the Lower Silurian, at Cincinnati, Ohio, and the surrounding country. It is also said to occur near the top of this series at Madison, Indiana, and Maysville, Kentucky, and fragments supposed to be of this species, have been found at near the same horizons in New York.

Glyptocrinus Dyeri, Meek.

Plate 2, fig. *a*, *b*.

Glyptocrinus Dyeri, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., Feb'y, p. 314.

Body globular-subturbinate, being wider than high, with sides rounding under to the base. Sub-basal pieces obsolete, or if present, not exposed externally. Basal pieces projecting as a thin rim below, very small, much wider than high, and presenting a trigonal general outline, though the lateral angles are doubtless minutely truncated. First radial pieces of moderate size, heptagonal in form, and wider than long; second and third a little smaller, the second being hexagonal, and the third pentagonal, and supporting on its superior sloping sides the first divisions of the rays. Secondary rays, or supraradial series, each composed of from eight to eleven pieces, that rapidly diminish in size upward to the second bifurcation, or commencement of the arms, just below which a few of the smaller pieces seem to be free and bear pinnulæ on their inner sides; farther down, the second and fourth supraradials of each ray give off alternately on each side small divisions, that do not become free, but are soldered into the interradial walls, though they can be traced to the summit of the body, where they merely give origin to pinnules.

Anal area a little wider than the interradial areas. First anal plate of about the same size as the first radials, hexagonal in form, and supporting, in the next range, three pieces, arranged with the middle one

higher than the others; while above these, three smaller pieces can be seen disposed in the same way in the third range, and three to four or five in the fourth; which is as far up as they can be traced. The middle plates of this series form a direct vertical row, that have a more or less prominent mesial rounded ridge extending all the way up from the middle of the lowest piece, of about the same size as those passing up the primary and secondary radial series; while the other plates on each side, and other parts of the lowest pieces, are ornamented with radiating costæ of smaller size, like those on the interradial pieces.

Interradial areas not excavated below, but becoming moderately concave above; first interradial pieces, of about the size of the second primary radials, hexagonal in form, and supporting two other somewhat smaller pieces in the next range, that bear between their superior, sloping sides a fourth smaller piece; while above these there are two pieces in the next range, that connect with the pieces of the little lateral divisions of the secondary radials, and perhaps with some other small intercalated pieces filling the upper part of the interradial areas.

Axillary areas flat, and each occupied below by a hexagonal or heptagonal piece of about the size of the second piece of each secondary radial; while the space above is occupied by several much smaller pieces.

Arms, four to each ray, rounded on the dorsal side, slender, of moderate length, very gradually tapering, simple, and composed of very short, slightly wedge-formed pieces, each of which bears at its larger inner lateral end a pinnule; pinnules slender, rather closely arranged, deeply furrowed on their inner sides, and apparently composed of rather long joints.

Surface of body-plates all ornamented with distinct radiating costæ starting from the center of each piece, and passing one to each of its sides so as to connect with others on each contiguous piece; of these costæ, those passing up the middle of each of the radial series are a little larger and more prominent than those of the interradial plates, while they bifurcate with the rays, so as to send a division up each of the secondary radial series, toward the upper part of which they become more prominent and rounded, being there of about the size of the free arms. Column unknown.

Height of body, 0.60 inch; breadth about 0.68 inch; length of arms, 1.05 inch; thickness of same, 0.05 inch; number of joints in a space of 0.10 inch near the base, eight.

This very beautiful species reminds one by its sculpturing of the common typical species *G. decadactylus*, from which, however, it may be at once distinguished by its proportionally broader and shorter body, with

sides rounding regularly under to the column, instead of being obconical. It also has proportionally more slender arms, and differs materially in having, in each secondary radial series, from nine to eleven pieces, between the first bifurcation of each ray and the arm-bases, instead of only two. In the form of its body, it agrees more nearly with *G. ornatus* of Billings, but it differs materially from that species in having twenty arms instead of only ten, as well as in less important details.

The specific name was given in honor of C. B. Dyer, Esq., of Cincinnati, Ohio, to whom I am indebted for the use of the very fine specimens figured, and from which the description was also made out.

Locality and position: Cincinnati group of the Lower Silurian; about 100 feet below the tops of the hills, at Cincinnati, Ohio.

Glyptocrinus Dyeri, *Var.* sub-globosus, Meek.

Plate 2, fig. 2 *c*.

Glyptocrinus Dyeri, Meek, 1872; Proceed. Acad. Nat. Sci., Philad.

There are in Mr. Dyer's collection some specimens agreeing almost exactly in structure with *Glyptocrinus Dyeri;* but differing in the form of the body, which is less rounded below, while their arms, and the ridges extending up the radial and anal series of plates, are decidedly stouter, and thus impart to these specimens a more robust appearance. They also have a much thicker column. In general appearance, this form stands, as it were, intermediate between *G. Dyeri* and *G. decadactylus*. It differs, however, decidedly from the latter, and agrees with the former, in having ten to twelve secondary radials between the first bifurcation of each ray and the second division, instead of only two, as in *G. decadactylus*.

It is quite possible that this may be a distinct species from *G. Dyeri*, to which it is most nearly allied; but without having more specimens for comparison, I scarcely feel warranted in separating it more than as a variety.

Locality and position: Same as last.

Glyptocrinus Nealli, Hall.

Plate 2, fig. 3 *a*, *b*, *c*.

Glyptocrinus Nealli, Hall, ——; Descriptions New Sp. Crinoidea, etc., p. 2, dated Albany, Nov., 1866; also 1872, illustrations new issue, pl. 1, figs. 18 and 19.

Body obconoidal, somewhat wider above than the height, with the interradial and axillary spaces so deeply excavated as to impart a five-

angled appearance below, and a ten-angled outline above the first divisions of the rays. Sub-basal pieces well developed, so as to assume the character of basals, wider than long, and exposing merely a triangular, sometimes slightly protuberant surface, with the lateral angles minutely truncated. Basal pieces proportionally much larger, about as long as wide, and hexagonal in form. First and third radials of equal size, with a general pentagonal outline, about as wide as long, the first being wider below, and the latter above; second radials as long as the others, but narrower, and presenting a general oblong outline.* Secondary radials twelve to about sixteen in each series, four or five of the lower ones being larger, and proportionally longer, than those above (which are very short, free, and scarcely differ from the free arm-pieces); the second or third one having somewhat the character of an axillary piece, and giving off a small lateral division or series of pieces on the outer or interradial and anal sides, that do not become immediately free, but are soldered in with the interradials and anals to the top of the body, where they each merely give origin to a pinnule like those of the arms.

Interradial areas occupied by numerous (70 to more than 100†) small pieces of very irregular size and form, and without any definite arrangement. Anal series less numerous (50 to 60), and still more unequal in size, the middle row being decidedly larger and more prominent than the others, so as to form a ridge up the middle of the anal area; while the other smaller and less prominent ones are crowded in irregularly on each side. Axillary areas each occupied by about fifty to sixty very small, irregularly arranged, unequal pieces. Vault composed of numerous minute pieces, generally of hexagonal form; highest on the anterior side, with a ridge radiating to each arm-base, and a corresponding sulcus between; opening minute, penetrating a small tubercle situated behind the middle, and directed backward.

Arms twenty, long, slender, rounded, gradually tapering, and simple, above their origin on the last, free, secondary radials; composed of very short, slightly wedge-formed pieces, each of which (like those of the smaller free primary radials below) supports a pinnule at its thicker end within. Pinnules long, rather stout, closely arranged, and composed of joints apparently three times as long as wide.

Surface of body smooth, excepting strong ridges that start from the head of the column at the base of the sub-radials, on which they bifurcate

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* In one specimen this piece is abnormally wanting in one of the anterior lateral rays.

† The number of all these interradial and axillary pieces here given is greater than stated by Prof. Hall, but the specimens vary much in this respect.

and send a branch to each of the primary radial series, and on these they unite and ascend as five prominent ridges to the last piece of each of these series, where they bifurcate and send a branch up each secondary radial series.

Column more or less distinctly pentagonal, and composed of alternating thin and somewhat thicker pieces.

Height of body to the commencement of the first free primary radials, on the anterior side, 0.77 inch; breadth at same point, about 0.65 inch; thickness or breadth of free primary radials, 0.08 inch; do. of arms at base, 0.06 inch; length of arms unknown; thickness of column at base, 0.13 inch.

This is a very distinct species from all of those previously described. In the general form of its body it does not differ much from *G. decadactylus*, but it differs materially from that species in having its interradial, anal and axillary spaces deeply excavated and occupied by much more numerous, smaller, and non-costated plates. It likewise has a much larger number of secondary radials in each series, and seven or eight of the upper ones in each free, and bearing pinnulæ like the arms, instead of having them all soldered as a part of the walls of the body, up to and above the second bifurcation of the rays.

The remarkable development of the sub-basal pieces of this crinoid, so as to give them the character of basals, and the great number and rudimentary character of the minute interradial pieces, are characters showing a decided approximation toward *Reteocrinus* of Billings, in which the interradial pieces are apparently entirely obsolete.

Locality and position: Upper part of the Cincinnati group, near Lebanon, Ohio. I am under obligations to J. Kelley O'Neall, Esq., of Lebanon, for the use of the fine specimens of this species, from which the figures and description are given.

Glyptocrinus parvus, Hall.

Plate 2, fig. 4 *a*, *b*.

Glyptocrinus parvus, Hall, 1872; Illustrations accompanying a re-issue of "Descriptions of New Sp. Crinoidea," etc., pl. I., fig. 17, without a description.

Body small, obconoidal, with interradial spaces a little flattened. Sub-basal pieces undeveloped, or very small. True basals, comparatively large, with a general pentagonal outline. First radials a little larger than the basal pieces, and heptagonal in form; second and third a little smaller, the

former hexagonal, and the latter apparently pentagonal or hexagonal, and supporting on each of its superior, sloping sides, in direct succession, two rather large secondary radials, the upper of which are each axillary pieces, and bear two arms, that are apparently free from near their bases.

First interradials nearly as large as the first radials, hexagonal in form, and each bearing two pieces in the next range, above which there are two or three smaller pieces in each area. Anal area not exposed in the specimens studied. Axillary spaces apparently occupied by one or two small pieces.

Arms twenty, slender, and near their bases composed of pieces that are nearly twice as long as wide, but which gradually become proportionally shorter and more wedge-formed farther up, so as to be about as long, at their longer ends, as their breadth; the larger ends being alternately on opposite sides, and bearing, along the inner margins, comparatively rather stout pinnules.

Surface of body scarcely costate, but with the primary and secondary radial pieces more prominent than the others, so as to form ridges. Column round at its connection with the base. Vault unknown.

At a first glance this species might be mistaken for a young *G. decadactylus;* but it differs from that species, not only in being much smaller, and in having a proportionally shorter body, but in having its arms apparently free from their origin on the last secondary radials. Its arm-pieces are also proportionally decidedly longer and its pinnules stouter and less closely set; while its body-plates want the distinct radiating costæ of *G. decadactylus.*

The only specimens of this species I have seen are somewhat crushed and distorted by accidental pressure, so that the characters given in the foregoing description may be found not to be *exactly* correct, in all the details, though they seem to be as given.

Locality and position: Cincinnati group of Lower Silurian, at Cincinnati, Ohio. Mr. Dyer's collection.

Glyptocrinus Baeri, Meek.

Plate 2, fig. 1 *a*, *b*.

Glyptocrinus Baeri, Meek, 1872; Am. Jour. Sci. and Arts, Vol. III., (3d series), p. 260.

Body of about medium size, globose-obconoidal. Sub-basal pieces apparently not developed, or very small. Basal pieces short and pentagonal. First primary radials of comparatively moderate size, presenting a general heptagonal outline; second a little narrower than the first, but of nearly

the same length, with a general quadrangular form; third slightly larger than the second, and pentagonal in general form. Secondary radials consisting of about four pieces in succession on each upper sloping side of each third primary radial; the first two or three of each series only about one-third smaller than the second primary radials, while above these the succeeding pieces soon become much shorter free brachials. Interradial pieces numerous, small, of very unequal size, and without any regularity of arrangement. Anal series unknown, but probably consisting of a mesial series of hexagonal pieces resting one upon another, and many much smaller pieces irregularly arranged between these and the radials on each side. Axillary spaces each occupied by some six or more small pieces.

Arms ten, rather long, simple, widest a little above their bases, and then gradually tapering to their ends; composed of very short pieces, so strongly cuneiform as to appear almost to taper to nothing alternately on opposite sides, while each supports a pinnule at its thicker end. Pinnules very long, moderately stout, nearly in contact, and composed of pieces that are three to four times as long as wide.

Surface of body-plates without costæ or striæ; those of the primary and secondary radial series more prominent than the much smaller pieces filling the interradial and axillary spaces, and thus forming somewhat flattened ridges, more or less interrupted at the sutures, and abruptly beveled at the sides; interradial and axillary areas roughened by a minute projection on each of the little pieces filling the same.

Column of moderate thickness, apparently nearly round, or perhaps sometimes sub-pentagonal near the base, and composed of alternately thicker and thinner pieces, the former of which project a little beyond the others.

The body of the only specimens of this species I have seen are too much distorted by pressure to afford very accurate measurements, but it seems to be about 0.45 inch in height, by a little less in breadth; while its arms measure 0.07 inch in breadth at the widest part, a little above the body, where about eight arm-pieces may be counted in a length of the same space.

This species will be readily distinguished from all of the described forms of the genus resembling it in other respects, by having only ten simple arms, and by the large number and small size of its interradial pieces. In the latter character it resembles *G. Nealli* of Hall, from which, however, it differs very decidedly in almost every respect; but more particularly in having only ten, instead of twenty arms, which are also stouter. Its interradial and axillary spaces likewise differ materially in

not being distinctly excavated, and in having each of the little pieces by which they are filled provided with a little projecting point.

The specific name was given in honor of Dr. O. P. Baer, of Richmond, Indiana, to whom I am indebted for the use of the specimens from which the figures and description have been prepared.

Locality and position: Upper part Cincinnati group of Lower Silurian, at Richmond, Indiana.

CYSTOIDEA.

Genus LEPOCRINITES, Conrad, 1840.

(Ann. Report Palæontol., N. Y., p. 207.)

Lepocrinites Moorei, Meek.

Plate 3, fig. 4 *a*, *b*, *c*.

Lepocrinites Moorei, Meek, 1871; Am. Jour. Sci. and Arts, Vol. II., p. 296, 3d series, (issued Sept. 29, for Oct., 1871.)

Body obovate. Base forming nearly one-fourth the height of the body, with its four pieces each about as long as wide, and of nearly equal size; three of these pieces being irregularly pentagonal in form, and one on the anal side hexagonal. Plates of the second range alternating with the basal pieces, excepting one on the anal side, which is longer than the others, cuneate-pentagonal in form, and resting on the upper slightly concave side of the hexagonal basal piece, while its narrow end extends up to the lower margin of the anal opening; succeeding piece on the left of that just described, of equal or slightly greater length, and heptagonal in outline, with one of its short upper sides forming a part of the margin of the anal opening;* the other three pieces of this range are about as long as wide, two hexagonal, and one apparently heptagonal. Plates of the third range, of very unequal size and form, and all alternating with those of the second range, excepting one on the anal side, which rests on the short upper side of the largest heptagonal piece of the second range, forms a part of the margins of the anal opening, and also extends upward so as to compose a part of the upper side or vault of the body; two of the others have an oblong sub-hexagonal form, one a more regular hexagonal

* This opening is often called the ovarian aperture; but this is against all analogy, if we can judge from the known method of reproduction in the existing *Crinoidea*. Differences of opinion also exist in regard to whether it was simply an anal opening, or both anal and oval. The former seems to me to be the most probable.

outline, and the fifth, which is largest, a trapezoidal outline. Fourth range, although in part curved and extending downward so as to form a portion of the lateral walls, also extend upward and forming the top or vault of the body.

Pectinated rhombs four, comparatively large, and, as usual, each composed of a pair of elongate-subtrigonal openings, protected each by fifteen to twenty little transverse bars. Lower rhomb at the base of the anterior side of the body, with its lower half near the margin of one of the basal pieces, and the other near the contiguous margin of one of the next range of pieces above. Two of the other three rhombs situated on the right side of the body, mainly above the middle, in such a manner that their longer diameters diverge upward at an angle of 45°, a half of each being placed, one near each of the lower sloping margins of a plate that extends up and forms a part of the vault, and the other two halves occupying the upper margins of each of the two contiguous plates of the third range just below. Fourth rhomb on the left side of the body, with its longer diameter ranging horizontally on a line with the anal opening, and so situated that its upper half is at the lower margin of a plate forming a part of the vault, and the other half near the upper margin of the third range just below.

Arms five, recumbent, and very short, so as to be confined mainly to the top of the body, where they occupy very shallow, scarcely perceptible, smooth depressions in the surface of the vault plates; arranged so that one extends backward and downward nearly to the anal opening, another to the two rhombs on the right side, a third to the right margin of the rhomb on the left, and two others diverge forward; each provided with a distinct, slightly flexuous, ambulacral furrow, and composed of about ten alternating pieces, exclusive of an axillary piece between each two of of their inner ends. Pinnulæ unknown.

Anal opening large, round, with beveled margins, and placed about one-third the length of the body below the summit of the posterior side; valvular pieces by which it was protected, unknown, excepting two minute pieces, each provided with a minute central tubercle, seen adhering to its lower margin, that probably belonged to that series, the others having been accidentally removed. Other apertures unknown.

Surface ornamented with small thread-like radiating costæ, one of which, passing from the middle to each side of each plate, is usually slightly larger than the others between.

Column round, at its connection with the base, comparatively large, composed of thin pieces, and provided with a large internal canal, but soon tapering to a smaller size, and composed of thicker segments below.

Height of body, 0.46 inch; breadth, about 0.36 inch; thickness of column at its connection with the body, 0.14 inch; and at a little more than 0.50 inch below, scarcely 0.07 inch.

This species seems to present essentially the characters of the genus *Lepocrinites*, excepting that it has four, instead of three pectinated rhombs, and five instead of four arms. Exactly how much importance should be attached to these differences, I am not fully prepared to decide, without specimens of several allied types at hand for comparison; though I am scarcely inclined to think these characters, even if normal in the only specimen I have seen, of generic importance. Prof. Hall includes under *Lepocrinites*, or *Lepadocrinus*, as he corrects the orthography of the name, *Apiocystites* of Forbes, and his own *Callocystites*, the first of which has four, and the latter five arms; but each of these, as well as the original type, has only three rhombs or pairs of pectinated openings.

Should the change in the orthography of the name of this genus be adopted, of course the name of the species here described would become *Lepadocrinus Moorei*.

The specific name was given in honor of Prof. Joseph Moore, of Richmond, Indiana, to whom I am under obligations for the use of the only specimen of the species yet discovered.

Locality and position: Upper part of the Cincinnati group of the Lower Silurian, at Richmond, Indiana.

Genus ANOMALOCYSTITES, Hall, 1859.

(Palæntol. N. Y., Vol. III., p. 133.)

Anomalocystites (Ateleocystites?) balanoides, Meek.

Plate 3 *bis*, figs. 6 *a*, *b*, *c*.

Anomalocystites (Ateleocystites?) balanoides, Meek, 1872; Am. Jour. Sci. and Arts, Vol. III. (3d series), p. 423.

The only specimens of this fossil that I have seen are in a bad state of preservation, being distorted by pressure, and only consisting of the lower portions of the body, and some of the extremely thin segments of the thickened part of the column connecting with the base of the same. One side of the body was evidently flat, or a little concave, and the other convex; and the entire outline, as seen on either of its sides, was probably oblong-suboval; while the lateral margins are distinctly carinated, at least toward the lower part of the body.

On the flat or concave side, the middle two pieces are elongate cuneiform, being widest below, and tapering upward, the length of each piece being a little more than twice its greatest breadth below, where they are each truncated obliquely upward and inward, with concave margins, to form a very profound, rounded sinus, for the reception of the large upper end of the column. The marginal pieces, one on each side of those just described, on the contrary (as seen on the flat side), taper downward with an inward curve, and do not quite reach the base of the lateral portions; while they appear to be shorter above than the middle pieces, their upper ends being apparently obliquely truncated (downward and inward) for the reception of an unknown piece above each, belonging to the next range; while they are abruptly deflected along the lateral carinæ, so as to appear as marginal pieces on the convex side of the body also.

On the convex side of the body, the lower range of plates consists of three large pieces, with a comparatively narrow face of the deflected and carinate marginal pieces on each side. The lower edges of the three large mesial plates are also sinuous, for the reception of the end of the column, but less deeply so than the central two on the flat side of the body. The central of these three pieces is the largest, somewhat coffin-shaped, and as long as the middle two pieces of the other side. It tapers from near the middle downward, to a narrow base, and also upward, more or less, from the same point, but the exact form of its upper part cannot be made out from the specimens studied. On each side of this middle piece there is a somewhat shorter piece, wider below, and tapering slightly upward, with its upper end truncated a little obliquely inward and downward, with a slightly concave margin, for the reception of a piece (the form of which is unknown) above each, in the next range, and connecting with each side of the middle plate above its middle. Outside of each of the lateral of these three pieces of the lower range, on this side, the comparatively narrow face of the marginal carinate piece is seen, and apparently extending upward a little farther than the lateral of the three larger pieces. The parts above those described, on both sides, are unknown.

The surface is finely and obscurely granulo-striated, these markings showing a tendency to run longitudinally on the marginal pieces, and transversely (but much interrupted and broken up) on the middle pieces of the flat side. On the convex side, they generally assume more the character of obscure irregular granules, excepting near the lower ends of the two lateral of the three principal pieces, where they become little regularly arranged, rather distinct, raised transverse lines.

The column was evidently comparatively very large at its connection

with the body, and composed of extremely thin pieces, that are not transverse, but (at least near the body) bent or deflected, so as to conform to the sinuous margins of the base of the body. It also seems probable that the habitual posture of the body, with relation to the column, was such that the two were not on a line with each other, but more or less flexed or bent, so that the column connected with the body obliquely, somewhat as in *Eucheirocrinus* (*Cheirocrinus*, Hall, 1860; not Eichwald, 1856). At least the much deeper sinus for the connection of the column, in the lower range of pieces on the flat side, than on the convex, would favor such a conclusion.

Length of body unknown, but it measures 0.93 inch in breadth, and about 0.40 inch in convexity, near the lower part; breadth of upper end of column, about 0.49 inch.

Although this fossil is evidently very closely allied to the genera *Anomalocystites*, and *Ateleocystites*, I am not entirely sure that it would be found exactly congeneric with either, if we had the means of comparing its entire structure with that of the types of those groups, which are *very* closely related to each other. It certainly differs conspicuously, however, at least in its specific characters, from the typical and only known forms of these groups. In the first place, it is much larger than the type of *Anomalocystites* (*A. cornutus*), and has the middle two pieces of its lower range of plates on the flat side proportionally longer—that is, longer than the marginal pieces, instead of the reverse. Its base is also more deeply sinuous on this side than in the New York species. On comparing its convex side with that of *A. cornutus*, we observe still more marked differences, the three principal plates of the lower range, in our type, being all decidedly longer than wide, instead of the reverse, and the middle plate considerably longer than that on each side of it; while the carinate marginal pieces, which are quite distinctly seen in this view of our species, are scarcely visible on this side of the New York species. There are doubtless also equally great differences in the structure and arrangement of the parts above on both sides, if we had the means of making comparisons of this part of the body.

In size, our species corresponds more nearly with *A. disparilis*, from the New York Oriskany Sandstone; but from what has already been stated, it will be seen to differ too widely in the form and proportions of its lower range of pieces, to render a comparison necessary.

Compared with *Ateleocystites Huxleyi* of Billings, the typical and only known species of that group (if it is distinct from *Anomalocystites*), our species will be found not only to differ in its much larger size, but also in

having its base greatly more widely and deeply sinuous on the flat side, for the reception of the column; while the central two pieces taper more rapidly upward, and are longer in proportion to the lateral ones. Its lateral pieces, on the contrary, taper more decidedly downward, and differ in having their lower ends curved inward. The convex side of *A. Huxleyi*, and the upper parts of our species being unknown, we have no means of carrying the comparison farther, but enough can be seen to show, beyond doubt, that the two forms are at least clearly distinct specifically.

Whether these several types belong to one, two, or three genera, it must be evident, I think, to any one accustomed to study these old types of the *Echinodermata*, that in a systematic classification or arrangement of the genera of the *Cystoidea* into families, they will have to stand together in a distinct family *Anomalocystidæ*, occupying a somewhat analogous position in this group to that of the family including *Eucheirocrinus*, of the *Crinoidea*.

Locality and position: Upper part of the hills at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian. The best specimen I have seen belongs to the collection of C. B. Dyer, Esq., of Cincinnati. I am also under obligations to Prof. O. C. Marsh, of New Haven, for the use of another more crushed specimen of the same, or an allied species. Both of the specimens mentioned were discovered, I am told, by G. W. Harper, Esq., of Cincinnati.

Genus LICHENOCRINUS, Hall.

Lichenocrinus, Hall, ——; Advance Sheets of Regent's Report, p. 9, dated Nov., 1866; Meek, in Am. Jour. Sci. and Arts, Vol. II. (No. 10, 3d series), issued Sept. 29, for Oct., 1871, p. 299; Hall, Advance Sheets Regent's Report, dated Oct., 1871, pp. 1 and 2, also figs. 1 to 7, plate 3, of illustrations of same, issued at a later date; Meek, Am. Jour. Sci. and Arts, Vol. III. (3d series), p. 15, Jan'y, 1872.

This curious fossil, found in the Cincinnati rocks, and first noticed by Prof. Hall, under the name *Lichenocrinus*, has attracted much attention, and various suggestions have been made to explain its anomalous structure. If really the *body* of a crinoid, it must certainly be one of the most remarkable and interesting types of that protean order of animals. Prof. Hall's generic description of this fossil first published, reads as follows:

"Bodies parasitic on shells and other foreign substances. Form discoid or depressed convex, with a proboscidiform appendage rising from the center. Disc composed of an indefinite number of polygonal plates, and apparently having no distinct mode of arrangement. Proboscis perforate,

and in the known species formed of five ranges of short plates alternating and interlocking at the margins."

After examining a number of specimens of the two known species of this type, during the summer of 1871, belonging to the collections of Mr. Dyer and other gentlemen at Cincinnati, I proposed, in a paper issued a few days before the end of September, in the October number of American Journal of Science and Arts, to extend the description of the genus as follows:

"Discoid or depressed plano-convex bodies, growing firmly attached to shells, corals, trilobites and other marine objects, and entirely destitute of free or recumbent arms or pinnulæ, ambulacral openings or pectinated rhombs. Free or convex side concave in the central region, and composed of numerous small, non-imbricating polygonal plates, without any definite arrangement; mesial depression provided with a long, slender, perforated, flexible, column-like appendage, composed of five longitudinal series of short, alternately interlocking pieces.* Attached side, when separated, presenting no sutures or openings,† but in some conditions showing numerous, distinct, regularly arranged, radiating striæ, corresponding to radiating lamellæ that occupy the whole internal cavity from top to bottom."‡

After this diagnosis, the following remarks and suggestions were added: "Among the more remarkable features of this fossil, may be mentioned its very curious system of radiating lamellæ occupying the whole internal cavity, and giving it, when the plates of the upper side are removed so as to expose these lamellæ in place and attached to the adhering side, almost exactly the appearance of the little fungoid coral *Micrabacia*. The entire absence, so far as known, of free or recumbent arms or pinnulæ, as well as of the most minute ambulacral or other openings, save the minute perforation into the slender, column-like appendage, and the attachment of this appendage to the free side of the firmly adhering disc, are also very anomalous features, if we view the disc as the body of a crinoid."

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* I subsequently ascertained that this alternate arrangement of these pieces is not always continued, well defined, all the way from the disc to the free end of this appendage.

† Since this was written, Mr. James has sent to me a detached specimen, that shows the whole under, or flat side, to be distinctly marked by numerous minute rhombic, suture-like markings. This character, however, seems to me to have been produced by the reticulations of some little coral, upon which the disc had grown, since others attached to smooth surfaces show the under side, when separated, to be smooth.

‡ A very fine specimen in this condition, examined at a later date, shows that these radiating lines on the under side of specimens in this condition really *alternate* with the lamellæ within, as will be noticed farther on.

"On examining one of these fossils, one of the first questions that suggests itself is, what can be the nature of this long, slender appendage, not more than four to eight or ten hundredths of an inch in diameter, and several inches in length? Is it homologous with the so-called proboscis or ventral tube of other crinoids, or with the column of the same? Prof. Hall evidently entertained the former opinion at the time he wrote the diagnosis quoted above, though I was informed at Cincinnati, that after seeing other specimens than those from which his diagnosis was written, he inclined to the opinion that it is a column. That one or the other of these views is correct, would almost necessarily seem to be the case, and yet there would appear to be rather strong objections to both of these conclusions, if we view the disc as the body of a crinoid. In the first place, if a column, why should the body, instead of being, as usual, attached by it, always (when not accidentally detached) be found growing firmly by the whole opposite side to foreign bodies, and this long appendage in all cases be left dangling free, and, if viewed as a column, apparently useless? Again, if a column, connected with the free side of an attached crinoid, how are we to account for the fact that no traces of any other opening than that passing in through this appendage can be seen, even by a careful examination under a magnifier, in any part of the body? In addition to this, it does not connect with the disc by a series of basal pieces, as is usually the case with the connection of the column of a crinoid or cystoid to the body of the same, but on the contrary, the plates of the disc diminish in size inward, and pass by easy gradations into those forming the base of this long appendage."

"On the other hand, if we proceed to view this appendage as a proboscis or ventral tube, connecting with the ventral side of the body, we are met by the objection of its extreme proportional length, slenderness, flexibility, and the fact that it seems to taper off nearly to a point at its free end. In Mr. Dyer's collection there is a piece, apparently of the free end of this organ, about an inch in length, and agreeing exactly in size, form and structure, with that of *L. Dyeri*, that is broken at one end, and tapers to a slightly blunted point at the other end, which is composed of very minute pieces drawn together. In other examples, where three or four inches in length of this appendage can be seen attached to the disc at one end, it tapers off until it becomes exceedingly slender at the free broken end. This character of its termination, especially when viewed in connection with its length, slenderness and other peculiarities, would seem to be a very strong objection to the conclusion that it is a ventral tube or proboscis. Still there might have been a minute opening at the extremity, closed by diminutive pieces, as we often see is the case with the opening of much larger crinoids."

"While examining specimens of this type, several solutions of the mystery of its structure suggested themselves, the first one of which was, that possibly the disc, viewed as the body, might really be only a peculiarly constructed root, or base of attachment of a crinoid, the body of which grew at the free end of the long column-like appendage. This suggestion receives some support from the fact that the disc, although usually growing on the flat surfaces of shells, etc., is sometimes found growing upon the side of the columns of other larger crinoids, as well as on other uneven surfaces, and in such cases it is bent around so as to conform to the curve of this surface of attachment, just as we see in crinoid roots similarly situated; while its whole interior is so filled with radiating lamellæ, as to leave extremely little space for the viscera of an animal, and is, as already stated, apparently hermetically sealed, excepting the minute canal leading up into the long appendage. It is true that the roots of crinoids are generally formed of thickened and anchylosed rings or segments of the column, but Mr. Billings has figured the root of one type (*Cleiocrinus grandis*), apparently composed of an accidentally folded expansion of minute polygonal plates; and it is worthy of note, that the column attached to this root is longitudinally divided by five sutures. It is also true, that there is no example, so far as known to the writer, of any such system of radiating lamellæ being connected with the root of a crinoid; but this objection would doubtless apply with even greater force against the conclusion that this disc is the body of one of these animals."

"On the other hand, among the strong objections to the suggestion that these discs are roots, may be mentioned their very regular, symmetrical form, and the fact that no indications of a body at the free end of the column-like appendage have yet been observed, nor of a detached body with adhering portions of a column agreeing with this; while no free crinoid that might have been attached to this column in its early stages of growth, is known in these rocks. In addition to this, the tapering and pointed extremity of this appendage would seem to render it at least improbable that it had ever supported a body at that end."

"Two other solutions of the difficulty suggest themselves, one of which is, that possibly the specimens, as we now see them, may not be the mature condition of the animal, but only one of the stages of development of some crinoid, which, if known in its adult condition, is supposed to be an entirely distinct type. The other is, that the discs, as we now see them growing fast to other bodies, may be the adult condition of a crinoid that in its earlier stages of growth was supported on its little column, as in other types, being otherwise free, and that at a later period

of its growth, the column became free at it its lower end, and was, for a time, trailed about by the floating body, which finally inverted itself and grew fast to other objects by what was originally its vault. The fact, however, that these discs attain a diameter of at least half an inch, with the elongated appendage four inches or more in length, would, even if known analogies supported such a view, seem to be a very strong objection to the conclusion that these are immature or embryonic forms; while, to say nothing of other strong objections that naturally present themselves against the last mentioned suggestion, the occurrence of these discs of all sizes, from the largest down to others less than a tenth of an inch in diameter, all alike growing fast to other bodies by the side opposite the column-like appendage, seems to demonstrate that this is their mode of growth from the first."

"In view of all that is now known of this curious fossil, it seems to me, without undertaking to express a positive opinion on the subject, that the weight of evidence (supposing that these discs are really the body of a crinoid) favors the conclusion that the long appendage is a ventral tube; but *if the appendage is a column*, then I should incline to the opinion that the disc is a peculiarly organized root, and that the body may be yet unknown, unless as an entirely distinct crinoid."

In some advance sheets of a paper issued after the publication of the remarks quoted above from the Journal of Science, Prof. Hall also noticed the peculiar character of the presence of internal radiating laminæ in this fossil, and makes the same remark, that they give the interior the appearance of a coral. He likewise makes the same suggestion, that possibly the disc may really be the root, instead of the body of the crinoid, and mentions the same objection (its form) to this conclusion. He farther suggests, in the same paper, that the animal may possibly have been capable of attaching itself temporarily by its flat side, and removing at will; and after mentioning the radiating lamellæ, adds, that "we may imagine that the spaces between these lamellæ may have been occupied by slender fleshy tentacula."

On examining the collections sent on by Mr. Dyer, after the publication of the paper already cited from the Journal of Science, including some specimens I had not previously seen, I again called attention, in a note published in the January number of the same Journal, to one of these specimens showing the long column-like appendage tapering off to a remarkable degree of slenderness, and mentioned the bearing this fact seemed to have against the conclusion that this organ properly corresponds to the so-called proboscis or ventral tube, or to the column, of other crinoids. I there also mentioned some

strong objections to the supposition that the animal may have possessed the power of attaching and detaching itself at will to and from other bodies by its flat side. These were the absence of any opening through the basal platform of the under side, and so far as yet known, of any traces of arms or pinnulæ. Consequently, if once detached, it is difficult to understand how the creature could have sought and adjusted itself to a suitable station; or, if accidentally brought into contact with such a surface, how it could have adapted and fastened itself so as exactly to conform to the slightest inequalities, such, for instance, as the striæ of a shell, or the lobes and depressions of the glabella of a trilobite.

If there were any openings in the basal layer or platform of its under side in immediate contact with the surface of attachment, and the body had possessed some degree of flexibility, we might suppose the adhesion could have been effected by suction; but all examinations of numerous specimens have entirely failed to detect the slightest traces of any openings through this thin basal layer or platform; while the rigid nature of the lamellæ within, would seem to preclude the possibility of any degree of flexibility.

One of Mr. Dyer's specimens, however, now before me, would, at a first glance, seem to throw doubts on the conclusion that the disc was not flexible. This individual is seen lying in the matrix in such a manner as to expose the under side, which had, by some means, been separated from the object to which it had been attached; while one of its edges is folded closely upon its exposed under side. A careful examination, however, by the aid of a good magnifier, fails to detect any gaping of the sutures, or disarrangement of the plates of the upper side along the folded edge, though some of these plates can be seen to curve a little, so as to adapt themselves to the curve of the folded margin. It must, therefore, be evident that this folding of the edge of the disc could not have taken place after it had attained its full size, flattened out as usual, but must have been produced as a deformity during its growth; and probably by some peculiarity of the station to which it was attached, such, for instance, as being situated upon, and near the edge of some thin shell, beyond the margin of which it projected as it increased in size, and then curving under, as it grew, so as to become folded against the under side of the thin bit of shell, which subsequently decomposed.

In this specimen, as in nearly all others showing the under side of the basal platform, this surface is smooth, and shows no traces of radiating striæ, excepting when moistened and examined by the aid of a magnifier, when, owing to its thinness and translucency, these striæ can be seen within. Another specimen that grew on the flat part of the cheek of a

large trilobite, but which had separated from this surface of attachment, shows, in the same way, its under surface, without any opening or striæ, but when moistened and examined with a magnifier, the radiating marks of the inner side can be seen through its thin, translucent substance.

Another specimen that I had seen in Mr. Dyer's collection, but which was not received by me for critical study for some time after all of the others mentioned, presents some features worthy of note here. In this alone, of all the specimens of this fossil I have seen, there is, in the flat or under side, a small central opening, due, as I must believe, to some accident, and radiating from this, numerous, regular, fine raised lines, with little linear furrows of the same size between them. In looking at this specimen alone (which has evidently been accidentally detached from the body upon which it grew), without any knowledge of others, one could scarcely entertain a doubt that this opening, situated so exactly at the center of radiation, must be the mouth, and the minute radiating furrows the ambulacral canals. A careful examination, however, under a magnifier, shows that the little raised lines between the furrows bifurcate regularly, sometimes twice or oftener, so that the furrows, in part, do not reach the central opening, but end abruptly at the points of bifurcation. Again, in numerous other instances, the basal layer of the disc can be seen still firmly attached to the original station, with the plates of the upper side, and the internal lamellæ wholly or in part removed, so as to show clearly the upper or inner side of the base, without the slightest trace of any central or other opening, and marked by numerous raised radiating lines corresponding to, or rather being the remaining parts of, the internal lamellæ. These can be, in part, traced very nearly to the centre, where, instead of an opening, there is often a little elevated point. It is also worthy of note that here, on the inner surface of these basal layers, these little radiating raised lines, left by the breaking away of the lamellæ, within the disc, do not increase by bifurcation, but by the intercalation of shorter ones between the longer; so that if we were to place the specimen mentioned above, showing the central opening and striæ of its under side, upon one of these basal layers (supposing both to belong to the same individual), the elevated striæ of its under side would conform exactly to the depressions or spaces between the raised radiating lines of the basal layer in such a manner that the little furrows would thus all be closed up.

If it were not for this fact, and the absence of any indications, so far as yet known, of any minute openings around the base of the periphery of the discs, at their connection with the bodies upon which they grew, I should be half inclined to suspect that there might be a double basal

layer, sometimes capable of accidental separation, with a central opening to an internal mouth through the upper one, and numerous minute ambulacral canals passing in to this opening *between the two layers.*

The bifurcating striæ on the flat under side of this specimen showing the opening, can hardly be, as I had at one time supposed, the edges of the internal lamellæ exposed by weathering, because their bifurcating character would seem to show that they do not coincide with the lamellæ within, but with the *interstices between them;* while there are no open slits between these striæ, as we would expect, if they were the edges of the lamellæ, but mere furrows.

Lichenocrinus Dyeri, Hall.

Plate 3, figs. 2 (and 3 *a, b?*)

Lichenocrinus Dyeri, Hall; Advance Sheets of Regents' Report, p. 9, dated Nov., 1866; and (1872) pl. 3, fig. 1-6, accompanying a re-issue of same.

Body depressed-discoidal, nearly circular, or obscurely pentagonal in outline; composed of a great number of very small, slightly convex, nearly or quite smooth pieces, of very unequal size and form, the larger ones often somewhat longer than wide, with their longer diameters directed inward and outward; central depression small; column-like appendage comparatively stout at its basal, or attached end, where it is sub-pentagonal, or nearly round, and composed of about five or six ranges of very short, distinctly and regularly alternating and interlocking pieces; perforation at base pentagonal, and scarcely equaling one-third the diameter of the appendage at that point. Interior unknown.

Diameter of apparently an adult individual, 0.32 inch; convexity about 0.09 inch; thickness of column-like appendage, at its connection with the body, 0.08 inch; length unknown.

Locality and position: Cincinnati group of Lower Silurian, near top of hills at Cincinnati, Ohio. Mr. Dyer's collection. Apparently rare.

Lichenocrinus crateriformis, Hall.

Plate 3, figs. 1 *a-t.*

Lichenocrinus crateriformis, Hall,; Advance Sheets of Regents' Report, p. 9, dated Nov., 1866; and (1872) fig. 7, pl. 3, of a re-issue of same.

Body discoid, with a sub-pentagonal or nearly circular outline; elevated and rounded near the margin, and broadly and distinctly concave in the middle; composed of alternating ranges of comparatively moderate sized,

generally hexagonal smooth plates as wide as long, around the convex outer part, and of much smaller pieces within the central concavity, that diminish in size inward to the base of the central appendage; internal rays slender, about one hundred, only a few of which quite reach the central point, the others ending at different and somewhat regularly arranged distances in from the periphery. Column-like appendage very long, slender, and tapering very gradually through its whole length, so as to end in an extremely slender mucronate point at the free extremity; more or less distinctly pentagonal, and composed of about five equal ranges of small, regularly and alternately arranged, interlocking pieces; but gradually becoming more rounded, with the pieces nearly or quite opposite, farther from the body: perforation small and pentagonal.

Diameter of the largest specimen seen, 0.35 inch, with a convexity of 0.08 inch. Diameter of another individual with a portion of the column attached, 0.15 inch; height of do., 0.05 inch; thickness of column-like appendage, near body, 0.04 inch; length of same to the broken free end, nearly three inches, with a diameter at same of 0.02 inch.

This seems to be much the more common of the two species; and will be readily distinguished from the last by its larger, less numerous, and more regularly hexagonal body-plates, as well as by its more distinctly pentagonal column, and the larger and deeper central concavity of its body. It is more frequently found growing on the surface of *Orthis testudinaria* than on other bodies, though it grew upon various other objects. One individual, belonging to Dr. H. H. Hill's collection, and represented by our figure 1 *b*, of plate 3, is growing in an almost exactly central position on the glabella of a *Calymene senaria*, and exactly conforming to the little inequalities of this part of the trilobite.

Locality and position: Ranges through most of the thickness of the Cincinnati group at that place, and for fifty or more miles from there in the surrounding country. Mr. Dyer's, Mr. James's, Mr. Shaffer's, Dr. Hill's and Dr. Byrnes's collections.

Genus HEMICYSTITES, Hall.

(Palæontol. N. Y., Vol. II., 245.)

Hemicystites stellatus, Hall.

Plate 3, figs. 8 *a*, *b*.

Agelacrinites (*Hemicystites*) *stellatus*, Hall; Descriptions of New Species of Crinoidea, etc., p. 8, dated Albany, Nov., 1866; also (1872) pl. 11, figs. 5 and 6, illustrations of same paper.

Body small, sub-pentagonal or nearly circular in outline, depressed discoidal. Disc composed of numerous small pieces, that are a little

convex, and apparently not distinctly imbricating. Rays extending from the middle, straight toward each of the five, obscurely defined, marginal angles of the disc, comparatively rather stout, slightly widest near the middle, and rather obtuse at the outer ends; each composed of a double series of alternating pieces two or three times as wide as long, and numbering about twelve on each side, in a specimen measuring 0.34 inch in diameter, without any intermediate intercalated smaller pieces; anterior ray abruptly tapering to a point at the middle of the disc, and the two posterior lateral ones more confluent at their inner ends with the two anterior lateral, and more distinctly separated by the deeper posterior interradial space. Opening situated in a little protuberance near the middle of the posterior interradial area.

Breadth of disc of largest specimen seen, 0.34 inch; breadth of arms at widest point, 0.06 inch; number of ray pieces on each side in same space, four to five.

This is the form referred to Prof. Hall's species by the geologists at Cincinnati, and doubtless belongs to the same, though it does not conform exactly to his description, since the sides of the disc do not rise vertically from the base of attachment in the specimens I have seen; while Prof. Hall does not mention the obscurely pentagonal outline of the disc seen in our specimens.*

Several authorities have placed *Hemicystites* of Hall as a synonym of *Agelacrinites*, Vanuxem. In this opinion, however, I cannot concur, as it seems to me that the much smaller size, and perfectly straight, proportionally wider rays of the forms for which the genus *Hemicystites* was proposed, ought to separate it generically from *Agelacrinites*.†

Specifically this form will be readily distinguished from the typical species of the genus *H. parasiticus*, from the Niagara group of the Upper Silurian, by its sub-pentagonal outline, non-imbricating, or at least much

* His figures, however, published since the foregoing remarks were written, show this character quite distinctly.

† Prof. Pictet, in his Traite de Palæont., vol. 4, p. 306, expresses the opinion that this genus and *Agelacrinites* probably ought to be united; and it is no wonder that he should have thought so, because he erroneously figures as an illustration of *Hemicystites*, under the name *H. parasiticus*, a true typical *Agelacrinites*, widely removed from the type of *Hemicystites*. Dujardin and Hupe, in their Hist. Nat. des Zoophytes Echinodermes, p. 84, follow Pictet in this error, and copy his figure of a true *Agelacrinites*, as *Hemicystites parasiticus*, giving the two genera as identical. They also fall into the additional error of citing *A. Hamiltonensis* of Vanuxem from the Middle Silurian, instead of from the Devonian (see note on the genus *Hemicystites*, by Meek and Worthen, Proceed. Acad. Nat. Sci., Philad., Dec., 1868, p. 357.)

less distinctly imbricating disc plates, as well as by its more petaloid rays, that do not taper inward regularly from the outer ends; and particularly by its more numerous and much less deeply interlocking ray pieces.

Locality and position: About 80 feet below the top of the hills at Cincinnati, or, in other words, above the middle of the Cincinnati group of the Lower Silurian, at Cincinnati, Ohio. Mr. Dyer's collection.

Hemicystites (Cystaster) granulatus, Hall.

Plate 3, figs. 9 *a*, *b*.

Hemicystites (*Cystaster*) *granulatus*, Hall, 1872; plate 11, figs. 1–4, and explanations of same, accompanying a re-issue of a paper of his dated Nov., 1866, in which this form was not described.

Body small, so much elevated as to present a short sub-cylindrical form, but rounded on the top, which is a little wider than the diameter below; the lower part presenting somewhat the appearance of a broad peduncle. Body and interradial areas covered by numerous very small grain-like pieces, that seem scarcely to present any appearance of an imbricating arrangement. Arms convex, short, and comparatively rather wide, the length being only about three times the breadth, curving from the central region over the rounded top, and extending downward about one-third the entire length of the body, where they terminate in rather blunt ends; composed each of about nine to twelve alternating, slightly oblique pieces on each side. Opening unknown.

Height, 0.30 inch; breadth near the middle (allowing for evident accidental lateral compression), about 0.16 inch; do. at top, 0.17 inch; length of arms, 0.16 inch; breadth of do., 0.05 inch.

I have seen only somewhat distorted specimens of this species, with the surface obscured by adhering shaly matter; consequently it is possible that some of the characters mentioned above may not be entirely natural. The species, however, will be readily distinguished by its remarkably elevated form, and very minute grain-like body pieces. Like the other species, it grows generally upon the surface of the valves of *Strophomena*.

Locality and position: Cincinnati Group of the Lower Silurian, at Cincinnati, Ohio. Mr. Dyer's collection.

Genus AGELACRINITES, Vanuxem, 1842.

(Report 3d Geol. Dist., N. Y., p. 158.)

Agelacrinites (Lepidodiscus) Cincinnatiensis, Roemer.

Plate 3, figs. 6 *a*, *b*.

Agelacrinus Cincinnatiensis, Roemer, 1851; Verh. Naturh. ver. fur Rhein. und Westph., Vol. VIII., p. 372, t. 2, f. 3 *a*, *b*; and in Brown's Lethea Geog., Vol. II., p. 275, t. 4, fig. 6; Hall, Descrip. New Crinoidea, etc., p. 6, dated 1866; and (1872) fig. 7, pl. II., accompanying a re-issue of same.

Body circular, depressed-plano-convex, or concavo-convex, the upper side being depressed-convex, and the lower a little concave, or more or less nearly flat, to conform to the surface of attachment. Disc composed of numerous thin squamiform plates, that imbricate inward from the periphery toward the center, those near the margins being proportionally shorter and wider than the others. Arms slender, depressed so as to be nearly or quite even with the surface of the disc; four sinistral and one dextral, composed of the usual double row of interlocking pieces, and (in large specimens) a series of much smaller intercalated supplementary pieces along the middle. So-called ovarian aperture situated near the middle of the largest interbrachial space surrounded by the dextral, and one of the sinistral rays, closed by about nine cuneiform pieces, with apparently nearly as many intercalated smaller ones, the whole, when closed together, forming a depressed circular prominence. Surface of plates nearly smooth.

Diameter of a rather large specimen, 0.77 inch; convexity, 0.15 inch; breadth of arms at their inner ends, 0.08 inch; breadth of the so-called ovarian aperture, 0.12 inch.

This is perhaps the most common, and the finest species of the genus, found in the Silurian rocks of the West. It is usually found growing upon the ventral valve of *Strophomena alternata;* but it sometimes grew on other objects.

I have before me a specimen, a little more than an inch in diameter, apparently of this species, belonging to L. B. Case, Esq., of Richmond, Indiana (found by him at that place), that seems to have grown on one of the valves of an *Ambonychia*. The shell had separated in such a manner as to take with it the under side of the *Agelacrinites*, and leave its upper side in the matrix so situated as to expose its inner surface. The inner side of each arm or ray is here seen to be composed of a single

series of quadrangular pieces that are not imbricating; while the disc plates near the outer margin show, on their inner surfaces, little parallel ridges, directed inward, and apparently fitting into coresponding furrows in the lapping edges of the contiguous pieces.

The distinctions between this and the other species of this horizon, will be mentioned in connection with the descriptions of the latter.

Locality and position: Near top of hills, at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian. The fine specimen figured belongs to the collection of Mr. Dyer. I am also under obligations to Mr. James, of Cincinnati, for the loan of a smaller individual of the same.

Agelacrinites pileus, Hall.

Plate 3, fig. 5.

Agelacrinites pileus, Hall; Descrip. New Crinoidea, etc., p. 7, dated Nov., 1866; also (1872) figs. 8 to 10, pl. II., accompanying a re-issue of the same.

Body circular, concavo or plano-convex, the upper side being very strongly convex, and the lower plane or concave to conform to the surface of attachment, which is usually the ventral valve of a large *Strophomena*. Disc composed of inward imbricating squamiform plates. Arms rather stout, very prominent, slightly wider near the middle than at their inner ends, and rather blunt at their outer extremities; all strongly curved in such a manner that four are sinistral, and one dextral; composed of stout sub-pentagonal pieces, that have their slightly longer diameters transverse to the arms, along the middle of which their inner ends alternately interlock, without any supplementary intermediate pieces between the two ranges. So-called ovarian opening situated a little outside of the middle of the largest interradial area surrounded by the dextral and one of the sinistral arms; pieces by which it is closed forming a distinct prominence, composed of about eight or ten trigonal and pointed pieces. Surface of body-plates smooth.

Diameter of body, 0.70 inch; convexity, 0.21 inch; breadth of arms at their ends, 0.06 inch; do. near middle, 0.08 inch; breadth of aperture, 0.12 inch.

This species will be readily distinguished from the last, by its more convex body, stouter and decidedly more prominent arms, which are more obtuse at their outer ends, and composed of thicker pieces, proportionally longer in the direction at right angles to the arms, without any supplementary pieces between. Its interradial areas are also distinctly

concave, instead of nearly flat, as in the last, and composed of a smaller number of pieces.

The specimen from which our figure and the foregoing description were prepared, appears not to agree exactly in form with the original of *A. pileus*, which is described as being "globose or globular-bell-shaped, and attached by the smaller extremity, which is composed of small squamiform plates." On the contrary, it differs but little *in form* from *A. Cincinnatiensis*, being only more convex. But as it is also stated in the same connection, that *A. pileus* "in specimens flattened from above, might readily be mistaken for *A. Cincinnatiensis*," it is probable that the individual here under consideration is an accidentally depressed example. It, however, does not present the slightest appearance of having been so flattened.

Since the above was written, I have seen a fine specimen of this species belonging to the collection of Mr. James Foster, of Cincinnati, Ohio, that was borrowed for my use by Mr. U. P. James. It is almost hemispherical, and shows very minute pieces around the lower margin of the disc. Above and between these and the ends of the rays, there are several ranges of much larger and wider pieces, which also exceed in size those between the vans, on the top of the disc or body.

Locality and position: Above the middle of the Cincinnati group of the Lower Silurian, at Cincinnati, Ohio. The figured specimen belongs to Mr. Dyer's collection.

Agelacrinites vorticellata, Hall.

Plate 3, figs. 7 *a*, *b*.

Agelacrinus vorticellata, Hall; Advance Sheets of Regents' Report, dated Dec., 1866, p. 7; and (1872) re-issue of same, pl. II., figs. 11, 12 and 13.

Body circular, depressed-convex above, and flattened or concave below, to conform to the surface of attachment. Disc composed of very small pieces. Arms comparatively very large, stout, prominent, and all strongly curved sinistrally, so close together as to leave very little of the disc exposed; composed of stout pieces a little thickened at each end, two or three times as long as their diameter in the direction of the length of the arms, along the summits of which their inner ends alternately interlock, without any intermediate supplementary smaller pieces between the inner ends of the two rows.

Greatest diameter, about 0.58 inch; breadth of arms, about 0.10 inch.

This species will be readily distinguished from the others yet known,

by its very large, thick, prominent arms, all curved sinistrally; their large size and strong curvature bringing them so close together as nearly to hide the disc. The only specimen I have seen does not show the so-called ovarian aperture, but it is said by Prof. Hall to be minute, and situated near the base of the posterior lateral rays.

Locality and position: Same as last. The figured specimen belongs to the collection of Mr. Dyer.

ASTEROIDEA.

Genus PALÆASTER, Hall.

(Palæontol. N. Y., Vol. II., p. 247.)

Palæaster? Dyeri, Meek.

Plate 4, figs. 2 *a–f.*

Palæaster? Dyeri, Meek, 1872; Am. Jour. Sci. and Arts, Vol. III. (3d series), p. 257.

Among the specimens loaned to me for study and description by Mr. Dyer, there is a very imperfect example of one of the largest known species of Silurian Star-fishes. When entire, it could scarcely have measured less than five inches in diameter, across from end to end of the rays on opposite sides; and it presents a breadth of disc (as flattened by pressure) of about two inches. Its state of preservation is, unfortunately, such as not to admit of systematic description, but I think enough of its character can be given to enable the student to identify it, by the additional aid of figures.

The dorsal side of both disc and rays is composed of numerous small pieces, with the pores between them apparently so large that these pieces only seem to touch at three to four salient points of each, so as to form a kind of reticulated structure; while they each bear a little central tubercle, with a minute pit in its top for the articulation of small, short spines, generally about 0.07 to 0.09 inch in length, and about 0 02 to 0.03 inch in thickness.

In one of the axilla between two of the rays the so-called madriporiform body can be seen near the margin of the disc. It is nearly flat, of an obtusely sub-trilobate form, with a breadth or transverse diameter of 0.30 inch, and a diameter at right angles to the same of 0.24 inch. Its lobed edge is directed inward toward the middle of the disc, and its middle lobe is largest, and shows the little divisions between the slits or furrows, diverging and bifurcating inward like the nervation in the pin-

nules of some kind of ferns; while in the smaller lateral lobes these markings diverge outward.

The ventral side is also much obscured by the adhering matrix, and numerous detached and confusedly mingled spines. A row of comparatively small, tumid, nearly square marginal pieces, however, can be seen in places, on each side of the ambulacral furrows, and alternating with a row of similar but slightly smaller adambulacral pieces, the number of pieces in each side of these series being about the same. The marginal pieces seem each to connect with the adjacent range of dorsal pieces, at places in the rays, by a little central salient point only, while those of both series are roughened by numerous comparatively coarse granules, and each piece (especially of the marginal row) also shows a small central pit for the articulation of a spine. These spines are larger than those connected with the dorsal pieces being generally about 0.22 inch in length, and 0.05 inch in thickness; they are smooth, straight, rounded, slightly thickened at the attached end, and tapering at the free end to a slightly blunted point.

The specimen is too much crushed and obscured to show the under side of the body, consequently nothing is known in regard to the nature of the ambulacral or oval pieces. Near the margin of the disc, however, between the inner ends of two of the rays, a few pieces can be seen within the marginal row that certainly seem not to belong to the adambulacral series. These may possibly be disc pieces. They are nearly or quite as large as the marginal pieces, and do not appear to form more than one, or possibly two ranges, while they seem to be confined to the axillary angles, there being no evidence that they extended outward along the rays.

The condition of the only known specimen of this species is such as to leave some doubts in regard to its generic characters, and for that reason I would have preferred to leave it until better specimens could be found. As Mr. Dyer desired, however, to have it characterized, I have done so as fully as the nature of the specimen would permit. Possibly I should have called it *Petraster Dyeri*, for if the apparent presence of a few disc plates on the ventral side between the marginal pieces and the adambulacral, is not deceptive, it would, in that respect, conform to the structure of that group, and differ from *Palæaster*, as now understood; though I am inclined to think this appearance due to the accidental displacement of the parts at the point where there are some indications of a few disc pieces. In the apparently large size of the pores passing through between the dorsal pieces, it would also seem to differ from the typical forms of *Palæaster*—these openings appearing to be so large that the dorsal pieces

seem only to touch at mere points, as already stated, so as to form a kind of reticulated structure. The nature of the dorsal side of *Petraster* is not, I believe, certainly known, but in *Palæaster*, Hall, the dorsal pieces have always been illustrated as if close-fitting, and in the original description the genus was said to have the pores "penetrating the plates of the upper side," instead of passing in *between* them. As no such character, however, exists in any of the species I have seen in a condition to show the dorsal side, or has been mentioned or illustrated by the same author in any of his subsequently published descriptions or figures of species of this genus, or mentioned in any of his remarks on the group, we may infer that he would not now lay much stress upon that supposed character.

I have thought it barely possible that this form might not be distinct from *Palæaster granulosus* of Hall, but from its greatly larger size (that species being described as of medium size), and the fact that it seems to have about the same number of adambulacral as marginal pieces, instead of nearly twice as many of the former as of the latter, I am led to regard it as a distinct species. It is certainly distinct from the following form that I have referred doubtfully to *P. granulosa*.

Locality and position: About 100 feet below the top of the hills at Cincinnati, in the Cincinnati group of the Lower Silurian. Mr. Dyer's collection.

Palæaster granulosus, Hall?

Plate 4, figs. 3 *a*, *b*, *c*.

Palæaster granulosa, Hall; Advance Sheets extracted from Regents' 20th State Cab. N. H. Rep., and dated Dec., 1866, p. 285; also (1867) same p., Regents' 20th Report.

Palæaster granulosus, Hall, 1870; Revised edition same Report, p. 327.

Attaining a large size; rays (as a little depressed by accident) slightly more than twice as long as their breadth at their inner ends, and tapering regularly from the disc to their free ends, which are rather acutely angular; breadth of disc a little less than that of the inner ends of the rays. Marginal pieces convex, nearly or quite as long as wide, numbering on each side, in the whole length of each ray (1.40 inch), thirty-one. Adambulacral pieces, a size smaller, as long as wide, convex, and numbering on each side thirty-nine to forty; like those of the marginal series, each bearing a small spine, the largest of which are each about 0.14 inch in length, and 0.02 inch in thickness. Ambulacral pieces very short, or nearly three times as wide as long, apparently not alternating with the adambulacral pieces, and each provided with a rather sharp ridge across

nearly its entire breadth. Dorsal side of disc and rays composed of small tuberculiform pieces, of which about sixteen rows may be counted at about half way between the inner and outer ends of each ray, along the middle of which those of two or three of the rows are a little larger than the others; each dorsal piece bearing a minute, very short spine. Surface of all the pieces minutely granular, one of the central granules always being somewhat larger than the others for the articulation of a spine. Oral pieces and madreporiform body unknown.

Although this fine Star-fish agrees pretty well in most of its characters with the description of *Palæaster granulosus* of Hall (which has not yet been figured), I am far from being entirely satisfied that it is really the same, as it seems to differ in some important respects. For instance, the rays of *P. granulosus* are described as being "obtusely rounded at the extremities;" while in the form under consideration they are rather acutely rounded, if not angular. Again, instead of having twenty-five of the marginal pieces on each side, in a space of one inch and a quarter from the apex of each ray, and forty-two or forty-three of the adambulacral, it shows in this space *twenty-eight* marginal, and only *thirty-two* adambulacral pieces. The number of the latter being about ten less on each side in the same space—a rather decided difference, showing the inner row to consist of proportionally larger pieces. Its ambulacral ossicula seem to have the same proportional breadth and length as in the type of *P. granulosus*, and also have each a similar ridge across the middle; but these ridges do not show the zig-zag arrangement mentioned in the description of *P. granulosus*. Prof. Hall does not say how many rows of pieces are seen on the dorsal sides of the rays of his species; but he states that it is probably the same species that the Western Academy of Sciences sent out lithographs of, under the name *Asterias primordialis*. One of these lithographs, now before me, represents from eight to ten rows of these dorsal pieces, which is six or eight less than may be counted near the middle of the rays of our specimen.

In noticing this form in the Am. Jour. Sci., Vol. III. (3d series), p. 277, I proposed, in case it should be found distinct from *P. granulosus*, to call it *P. speciosus*. It will be at once distinguished from *P. Dyeri*, not only by its smaller size, but by its differently formed and closer fitting dorsal pieces.

Length of rays, 1.40 inch; breadth of do., 0.62 inch at base; breadth of disc, about 0.80 inch.

Locality and position: Cincinnati group, Cincinnati, Ohio. Mr. Dyer's collection.

Palæaster? Jamesii, Dana.

Plate 4, fig. 4.

Fossil *Asterias*, Graham, Anthony and James, 1841; Report to Western Academy of Natural Sciences, published in Am. Jour. Sci. and Arts, Vol 1 (2d series), p. 441.

Asterias Anthonii, Dana, 1863; Manual of Geology (1st edition), p. 221, with figure, but without description.

Palæasterina? Jamesii, Dana, 1863; Am. Jour. Sci. (2d series), Vol. XXXV., p. 295; also, 1864, in Man. Geol. (2d series), p. 221, with figure, but without description.

Palæaster Jamesii, Hall; Advance Sheets extracted from 20th Report Regents, and dated Nov. and Dec., 1866, p. 6; and in 20th Report Regents, 1867, p. 289; also in 2d edition same, 1868, p. 329.

Through the kindness of Mr. U. P. James, of Cincinnati, the discoverer of this fossil, I have now before me the original typical specimen, which I find not in a condition to be fully and systematically characterized, nor perhaps to afford the means of determining, beyond doubt, its generic affinities. It evidently attained a large size, and has a comparatively large disc, with its five rays rather broad at their inner ends, somewhat rapidly tapering, and apparently longer than the diameter of the disc. It evidently lies in the matrix in such a manner as to show the ventral side, but presents the appearance of having the marginal and disc plates of this side removed. The five pairs of oral pieces are seen in place, and proceeding outward from these can be seen a row of adambulacral pieces on each side of each of the rather wide ambulacral furrows. These latter pieces are nearly three times as long as their diameters in the direction of the length of the rays, and quite prominent at their inner ends, where they are articulated together by little processes and corresponding sockets or sinuses; while the outer two-thirds of each is flattened and distinctly more depressed than their inner ends. Outside of, and alternating with, the outer flattened ends of these adambulacral pieces, a row of nearly square, or more or less oblong pieces, may be seen all along the margins of the rays, and connecting at their axilla in such a manner as to leave room for several disc plates between them and the oral and inner adambulacral pieces. The pieces of this outer row have the appearance, or rather position and relations to the other parts, of a marginal series, but owing to the fact that they are much less prominent than the inner ends of the adambulacral pieces, and all flat, or even slightly concave on the under side, it is possible that they and the few disc plates mentioned may belong rather to the dorsal side of the fossil, and thus have their under sides exposed, by the removal of the marginal and disc plates of the ventral side. Even in that case, however, it is

probable that those seen along the edges really show the insides of the outer ends of the marginal pieces, curved upward and over so as to form the margins of the dorsal side. If this latter suggestion is correct, the marginal plates would seem to have been so long on the under side, when entire, as to lap upon and entirely conceal the flattened outer two-thirds of each adambulacral piece, when in place.

At some places within the ambulacral furrows, remains of ambulacral ossicula can be seen deeply interlocking with the inner ends of the adambulacral pieces, but their exact form, and the position and arrangement of the ambulacral pores, cannot be clearly made out in the specimen studied.

The two oral pieces of each of the five pairs are separated by deep sutures, and have an irregular form, being longer than wide, and, like the adambulacral pieces, which they somewhat exceed in size, flattened and depressed at their outer ends, and elevated into crest-like prominences farther in, with a lateral process or thickening on the outer side of each, in which a more or less distinct pit may be seen. At their inner ends they seem to connect with other parts occupying the oral opening, but the exact form and arrangement of these cannot be clearly made out in the specimen examined.

The surface, and the arrangement of the dorsal parts, are unknown; but they were probably armed with short spines, as some remains of little spines are seen in the matrix at the margin of the disc, at one place.

As the extremities of none of the rays can be clearly seen, the exact breadth of the whole fossil, between the ends of opposite rays, cannot be exactly given, but it is evident that the length of one of the rays, measuring from the middle of the disc, must have been a little more than two inches, and consequently that the diameter across from the extremities of opposite rays could not be less than about four inches. The breadth of the disc is 1.20 inches; and that of the rays at their inner ends, 0.70 inch.

In first publishing a figure of this fine star-fish, in the first edition of his Manual of Geology, Prof. Dana proposed for it the name *Palæasterina? Anthonyi*, in honor of John G. Anthony, Esq., formerly of Cincinnati, Ohio. On subsequently learning, however, that the typical, and only known specimen of the species, was discovered by U. P. James, Esq., of the same city, he proposed (in the Journal of Science), in justice to Mr. James, to change the name to *P. Jamesii;* which name has been continued, with the same figure, in all the subsequent editions of the Manual. It is still a disputed question, however, among Naturalists, whether

or not the publication of a figure and name, without a diagnosis, really establishes a species. Many high authorities say it does, while others maintain that it does not. All agree, however, that when a species is once established, under a name not previously used for another valid species of the same genus, neither the original author, nor any other, has the authority to change it, excepting possibly in a few peculiar cases differing entirely from this. Consequently, if the rule should finally prevail, that the publication of a name and figure, without a diagnosis, is sufficient to establish a species, we would have to admit that the name *P. Anthonii*, was regularly applied to this fossil; and the inflexible law of priority would compel us to retain it. If, on the contrary, it shall be definitely settled that a diagnosis also is, in all such cases, required, then we will be at liberty to comply with the author's desire, by adopting the later name, *P. Jamesii*, which I have here done provisionally.

In regard to the generic characters of this fossil, it is not easy to decide from the only known specimen. If it really had a few disc plates intercalated between the marginal and oral and inner adambulacral pieces, on the ventral side, as there are some reasons to believe may have been the case, its structure would conform to that of the genus *Petraster* of Billings, and the name should then be *Petraster Jamesii*, or *Anthonyi*. If there are no such intercalated pieces, however, it would seem to fall into the genus *Palæaster*.

Locality and position: Cincinnati group of the Lower Silurian, Cincinnati, Ohio. Mr. U. P. James' collection.

Palæaster incomptus, Meek.

Plate 4, figs. 5 *a*, *b*.

Palæaster incomptus, Meek, 1872; Am. Jour. Sci. and Arts, Vol. III. (3d series), p. 275.

Small; rays rather short, or only about once and a half as long as their breadth at their inner ends, and rapidly tapering to their outer extremities, which are somewhat obtusely angular. Disc equaling in breadth the length of the rays. Dorsal side of rays composed each of three? rows of pieces,* that are wider than long, about nine in each row, and increase rather rapidly in size inward to the margin of the disc, which is composed of smaller pieces; a few very minute pieces apparently

* In some rays there appear to be four rows, but this is probably due to the exposure of one of the marginal rows of the rays, by oblique pressure.

sometimes occur between the rows on the dorsal side of the rays. Surface of dorsal pieces a little granular, but apparently without spines. Madreporiform piece rather small, a little oval, or almost circular, nearly flat, and marked by fine, irregularly interrupted, radiating striæ. Ventral side unknown.

Greatest breadth across between the extremities of rays on the opposite sides, 0.90 inch; length of rays, about 0.35 inch; breadth of same at their inner ends, near 0.22 inch; length of madreporiform piece, 0.08 inch; breadth of do., 0.07 inch.

This species seems to be related to *P. matutinus*, Hall, but has proportionally shorter and broader rays, that are also less pointed at their extremities. Its dorsal pieces are likewise less close-fitting, and appear to have, at some points, a few very minute intercalated pieces between the rows of the rays; though this latter character is not very clearly visible in the specimen. A more important distinction is the absence, in the species under consideration, of the circle of stellately marked pieces seen on the dorsal side of the disc of *P. matutinus*, which, according to Prof. Hall's figure, published in the 20th Regents' Report, seems not to have the well defined madreporiform piece, readily distinguishable from all of the other dorsal pieces, as seen in the species under consideration. As in that species, this has the two inner marginal pieces that connect with each other at the axils of the rays, rather decidedly larger than any of the others, but of different form, being wider than long, instead of the reverse, or with their longer diameters arranged transversely, and each provided with a kind of mesial protuberance on the inner side.

The only specimen of this species I have seen, is firmly attached by its ventral side to a foliated expansion of coral, so as to conceal that side entirely. It was evidently lying dead at the bottom of the sea, on its back, when the coral commenced growing upon its ventral side, and the coral afterwards not only covered this entire side, but grew some distance beyond even the extremities of its rays. This gives the Star-fish the appearance of growing parasitically upon the coral; but this is manifestly not the case, because it is its ventral, and not its dorsal side, that is attached.

Locality and position: Cincinnati group of the Lower Silurian, at Cincinnati, Ohio. Mr. Dyer's collection.

Palæaster Shæfferi, Hall.

Pl. E, fig. 1.

Palæaster Shæfferi, Hall, 1868; Twentieth Report Regents, p. 284, pl. 9, fig. 1; also p. 326, pl. 9, fig. 1, new edition of same.

I only know this species from the figure and description cited above, and merely copy the figure to make this report as full and complete as possible on the Cincinnati star-fishes. It seems to be a rather neat species, with somewhat slender, pointed rays. No figure of its dorsal side has been published; but it is described in the Regents' Report as having this side of the rays composed of "three rows of subnodose plates, the outer ranges bearing a strong spine on each plate; the central range apparently destitute of spines." The marginal plates of its under side are a little larger than the adambulacral; and the ambulacral plates are somewhat peculiar, in being apparently nearly or quite as long, in the direction of the length of the rays, as their breadth.

Locality and position: Cincinnati group, Cincinnati, Ohio.

Genus STENASTER, Billings, 1858.

(Canadian Organic Remains, Decade III., p. 77.)

Stenaster grandis, Meek.

Plate 3 *bis*, figs. 7 *a*, *b*, *c*.

Stenaster grandis, Meek, 1872; Am. Jour. Sci. and Arts, vol. 3 (3d series), p. 258.

Attaining a rather large size. Body comparatively small, or only the breadth of the united inner ends of the five rays. Rays long, gradually tapering, slender, and very flexible; widest at their immediate connection with the body, where they are more or less depressed, but becoming terete farther out. Dorsal side of body and arms composed of numerous little pieces, usually of subtrigonal form, that rise into pointed tubercles, or sometimes assume almost the character of short spinules, and are arranged in quincunx, so as to form about eight rows near the middle of the rays, those of the outer two rows being a little larger than the others. Dorsal pores apparently rather large, and passing through between the concave sides of contiguous pieces. Ventral side of body unknown; that of the rays composed of the usual single row of transverse adambulacral pieces on each side of the well defined, deep, and

moderately wide ambulacral furrows. Adambulacral pieces rather more than twice as wide as long, with their longer diameters at right angles to the ambulacral furrows, and each projecting along the middle in the form of a kind of narrow crest, that rounds over from end to end; while they do not connect with each other by perfectly flat sides, but have little projecting processes and sinuses, apparently for the purpose of giving greater flexibility to the rays.

Breadth of body, 0.63 inch; length of rays, 1.90 inch; breadth of same at their connection with the body, 0.36 inch.

Not having seen the under side of the body of this species, I am not quite sure that it is exactly congeneric with Mr. Billings's typical specimens of *Stenaster*. It does not show the peculiar contraction of the inner ends of the rays, seen in his *S. Salteri*, from which it also differs in a marked degree, in the much greater length and slenderness of its rays. In these characters, however, it agrees more nearly with his *S. pulchellis*, though its rays are proportionally longer, and provided with a greater number of rows of dorsal pieces, while it attains a much larger size.

In the length, slenderness, and flexibility of its rays, this fossil presents points of similarity to the *Ophiuroidea;* but it differs entirely in structure from that group, and conforms, in this respect, to the true *Asteroidea*. The apparently articulated character of its adambulacral pieces, is a peculiar feature, that may possibly be found to be accompanied by other points of structure, that may separate it generically from *Stenaster;* but this peculiarity cannot be confounded with the articulated character of the arm-pieces in the *Ophiuroidea*.

There are some appearances of the remains of very short spines being in some way connected with the adambulacral pieces; but on this point, or at least in regard to the exact nature of their connection, I have not been able to decide from the specimen studied.

Adopting the suggestion of Prof. Hall, that *Stenaster* of Billings should be replaced by the name *Urastrella* of McCoy, previously proposed for apparently congeneric forms, the name of the species here described would, if my present views of its affinities be correct, become *Urastrella grandis*.

I am under obligations to Mrs. M. P. Haines, of Richmond, Indiana, for the use of the typical specimen of this fine star-fish. It may not be out of place to mention in this connection, that this lady has, by her own zeal and industry, succeeded in getting together one of the finest and most valuable private collections of fossils and minerals in the West.

Locality and position: Upper part of the Cincinnati group of the Lower Silurian, at Richmond, Indiana. Mrs. Haines' collection.

OPHIUROIDEA.

? Genus PROTASTER, Forbes, 1849.

(Memoirs Geol. Survey Gr. Brit., Decade 1, part IV., p. 1.)

Protaster granuliferus, Meek.

Plate 3 *bis*, figs. 8 *a*, *b*.

Protaster? granuliferus, Meek, 1872; Am. Jour. Sci. and Arts., Vol. III. (3d series), p. 274.

Disc small, apparently circular; rays rather slender, and of unknown length. Dorsal surface of disc and rays covered by an integument composed of minute grains of calcareous matter. Ventral side of disc not well exposed in the only specimen seen, but apparently provided, in the interradial spaces, with minute spines directed outward. Oval pieces not clearly seen in the specimen. Arm-pieces regularly alternating, but apparently rectangular at their inner ends, and not interlocking along the impressed mesial line, longer transversely than in the direction of the length of the arms; each largely excavated at its outer anterior end, so as to form a large pore, or pore-like depression, and divided transversely by a furrow into two parts, the anterior of which is very short, and the posterior longer, and marked by a minute pit at its inner end; about eight or nine of these pieces in each range of each ray included within the disc. Outer arm or ray pieces (adambulacral of some) smaller than those of the inner ranges, and placed edge upward, with an oblique, outward direction, so as to imbricate outward, or toward the extremities of the arms; each bearing one or more minute, articulating spines.

Breadth of disc, about 0.43 inch; breadth of arms at their inner ends, 0.10 inch.

The only specimen I have seen, that is certainly known to belong to this species, is very imperfect, being merely an incomplete disc, and the inner ends of the rays. It does not conform to the characters of *Protaster*, given in Prof. Forbes' diagnosis, in all respects, since its disc, especially on the upper side, is covered by a shagreen-like integument, composed of a vast number of very minute grains of calcareous matter, instead of distinct imbricating scales. It is, therefore, probable that perfect specimens might show other characters that would warrant the establishment of a new genus, or sub-genus, for such forms, for which group I suggested, provisionally, the name *Alepidaster*, in the Journal of Science cited.

I have intentionally avoided, in the foregoing description, the use of the terms ambulacral and adambulacral pieces, sometimes used in describing the parts composing the rays of *Protaster*, and similar forms, because it seems doubtful whether these terms are properly applicable to such types. I should certainly think that they are not, *if those forms belong to the Ophiuroidea* (in which no ambulacral furrows exist), instead of to the *Asteroidea*. According to Dr. Wright, however (see Brit. Foss. *Echinodermata*, p. 32), *Protaster Miltoni* of Salter has a well developed madreporiform body, and hence would belong to the *Asteroidea*. Yet it is very curious that these types seem to have no proper ambulacral canals; and we have, apparently, no positive evidence that the viscera of the animal were not entirely confined to the disc, as in the *Ophiuroidea*.

Locality and position: Middle part of the Cincinnati group of the Lower Silurian, at Moore's Hill, Indiana. Mr. Dyer's collection.

MOLLUSCA.

POLYZOA.

Genus PTILODICTYA, Lonsdale, 1839.

(Murchison's Sil. Syst., p. 130.)

Ptilodictya (Stictopora) Shafferi, Meek.

Plate 5, figs. 1 *a*, *b*, *c*.

Ptilodictya (*Stictopora*) *Shafferi*, Meek, 1872. Proceed. Acad. Nat. Sci., Philad., Feb., p. 317.

Polyzoum small and delicate, consisting of slender, compressed divisions that give off on each side, rather closely arranged, regularly alternating, lateral branches of the same breadth as the main stems, from which they diverge at an angle of about forty degrees; lateral branches, in the same way, giving off on each side, very short, lobe-like, alternating projections; flattened lateral margins of all parts very narrow, sharp, and minutely striated longitudinally, in well preserved specimens; pores apparently without raised margins, more or less oval longitudinally, alternately disposed in longitudinal and oblique rows, so as to present a quincuncial arrangement; the number of longitudinal rows varying from five to about seven in the breadth of a stem or branch; spaces between the pores measuring transversely to the stems and their divisions about equal to the breadth of the pores, but greater, measuring in the direction of the oblique and longitudinal rows, all ornamented, in perfectly preserved specimens, by very minute, more or less waved or flexuous striæ.

Size of entire polyzoum unknown; breadth of stems and branches, 0.05 inch; number of pores in 0.05 inch; measuring in the direction of the oblique rows, about 4 to 6, and in the same space measuring longitudinally from 3 to 4.

This very delicate little species will be readily distinguished from the other known Silurian form by its small size and peculiar plumose mode of growth; and particularly by its very minute striæ between the pores. *Stictopora raripora*, Hall, from the Clinton group of New York, is as delicate a form, but differs materially in its mode of growth, and particularly in its very much less numerous pores.

The specific name is given in honor of Mr. D. H. Shaffer, of Cincinnati, Ohio, to whom I am indebted for the use of a fine specimen of the species, found, I am informed, by T. W. Spurlock, Esq., of Cincinnati. I also have good specimens of this species from Mr. Dyer's collection.

Locality and position: Toward the lower part of the Cincinnati group of the Lower Silurian, at Cincinnati, Ohio.

BRACHIOPODA.

Genus LEPTÆNA, Dalman, 1828.

(Kongl. Vet. Acad., Handl., p. 94.)

Leptæna sericea, Sowerby?

Plate 5, figs. 3 *a* to *h*.

Leptæna semiovalis, Conrad, 1838; Ann. Geol. Report N. Y., p. 115 (without figure or description).

Leptæna sericea, J. de C. Sowerby, 1839; Sil. Syst., pl. XIX., figs. 1, 2; de Verneuil, 1845, Geol. Russia, Vol. II., p. 227, pl. XV., figs. 1 *a*, *b*; McCoy, 1846, Sil. Foss. Ireland, p. 27; Barrande, 1847, Sil. Brach. Bohem, Naturw. Abhandl., Vol. II., p. 71, pl. XXI., fig. 18; Hall, 1847, Palæont. N. Y., Vol. I., p. 110, pl. XXXI. B, figs. 2 *a–h*, and p. 287, pl. LXXIX., figs. 3 *a*, *b*; Phillips and Salter, 1868, Mem. Geol. Survey, Vol. II., p. 285; McCoy, 1852, British Pal. Foss., p. 237; Salter, 1859, Siluria, 3d ed., p. 210, fig. 6 and pl. V., fig. 14; Eichwald, 1859, Leth. Rossica, Vol. I., p. 870; Salter, 1866, Mem. Geol. Survey, Vol. III., p. 266; Davidson, 1871, Monogr. Brit. Sil. Brach., p. 326, pl. XLVIII., figs. 10–19.

Orthis sericea, Eichwald, 1840; Sil. Syst. in Esthl., p. 157; Portlock, 1843, Geol. Lond., p. 450, pl. XXXII., figs. 23, 24.

Strophomena sericea, Conrad, 1840; Ann. Geol. Rep. N. Y., p. 201; Emmons, 1842, Geol. Rep., 394, cut 105, fig. 1.

Shell small, transverse, semi-oval, approaching semi-circular, concavo-convex; hinge line equaling, or more frequently a little longer than the breadth of the valves at any point farther forward; lateral extremities

varying from somewhat acutely angular to nearly or quite rectangular, and not properly reflexed; anterior and lateral margins forming together nearly a regular semi-circular curve.

Dorsal valve concave, its deepest concavity being near the middle; beak not distinct from the cardinal margin; area narrow or nearly linear, and ranging at right angles to the plane of the valves. Interior showing cardinal margin to be minutely crenate toward the lateral extremities; cardinal process moderately prominent, and trifid, the middle division being most prominent, with a deep pit at its inner base; brachial? processes short, appressed, and widely divergent; muscular impressions generally obscurely defined, occupying an obcordate area, and separated from each other by two sub-parallel, narrow ridges, that sometimes coalesce near the base of the cardinal process; each impression usually nearly equally divided by a slender linear, straight ridge; anterior and lateral regions more or less roughened by minute, granular, radiating striæ.

Ventral valve moderately convex, being nearly evenly, but gently arched, along the middle from the beak to the front, and thus following so nearly the curve of the other valve as to leave but a very thin visceral cavity within; beak very small, or scarcely, if at all, distinct from the cardinal margin; area twice to three times as high as that of the other valve, inclined backward, or more or less nearly parallel to the plane of the valves; foramen arched over, near the beak, by a small false deltidium, and closed between this and the hinge margin by the prominent cardinal process of the other valve. Interior showing hinge margin to be obscurely marked with minute pits for the reception of the crenulations of that of the other valve; teeth small; muscular impressions long, narrow, separated behind by a short linear mesial ridge, and diverging and extending forward beyond the middle of the valve, with a moderately distinct dental ridge along the lateral margin of each; anterior and lateral regions granulo-striate.

Surface of both valves marked by numerous very minute, closely arranged radiating striæ, about every fourth, fifth, or sixth one of which is a little larger and more prominent than those between.

Length of a mature specimen, 0.36 inch; breadth, 0.65 inch; convexity, 0.12 inch. Some specimens proportionally a little more convex.

The little shell here described is the western form that has long been referred to *L. sericea* of Sowerby, with which it agrees quite well in its external characters. I have had no opportunity to compare it with British or other foreign specimens of Sowerby's species, but on compari-

son with Mr. Davidson's figures of the interior of that shell, I am led to doubt whether it is really the same species. At any rate, it certainly has a more prominent cardinal process than is represented by Mr. Davidson; while its hinge margin is more or less distinctly crenulated, a character neither illustrated nor mentioned by that author, in *L. sericea.* Again, the muscular impressions of its dorsal valve are proportionally smaller, and not so arched; while those of its ventral valve are narrower and more elongated, as well as less diverging, being in form more like those of *L. transversalis*, but much less diverging. In the crenulation of its hinge it also agrees more nearly with *L. transversalis*, from which, however, it differs entirely in the form of the muscular impressions of its dorsal valve, as well as in its more depressed form. I have likewise been unable to see, even by the aid of good magnifiers, any traces of the minute punctures between its striæ, mentioned by several authors in describing the species above alluded to.

Locality and position: This shell has a wide geographical, as well as a great vertical range, or at least it has been identified at various horizons from the Trenton Limestone to the Clinton group in New York, and it seems to have nearly the same range in the Western States. It is found at nearly all the localities in the West where the Cincinnati or Trenton group occurs. It is common at Cincinnati through all the beds exposed there, and occurs at higher horizons in this series at Oxford, Dayton, and numerous other places in Ohio; as well as at Richmond, Madison, and other places in Indiana. It also occurs in Iowa, Illinois, Wisconsin, Kentucky, Canada, etc. The specimens from which our figures and description were prepared are from Cincinnati, Ohio, and Richmond, Indiana, where it occurs in great numbers, often clustered together as if gregarious in its habits.

The typical *L. sericea* seems to have an equally great vertical and geographical range in the Silurian rocks of the Old World.

Note.—At the horizon of 150 feet above low water at Cincinnati, there occurs a very similar, but somewhat larger and proportionally wider shell, with a more straightened anterior margin, and the area of its dorsal valve more inclined forward. This form also often has rather distinct oblique wrinkles along the hinge margin on each side, of which only very faint traces are sometimes seen on the last. I have not seen the interior of its dorsal valve, but a single example of the ventral valve, showing the interior, has the muscular scars undefined, excepting as minutely striated spaces free from the granulations seen on other parts of the interior. Its brachial? processes are longer than in any specimens of the other form I have seen, but as these are very slender and free at the end in each, they may not be entire in the specimens of the other form examined. It was for this form that Mr. James proposed the name *L. rugosa* in his list of the Cincinnati fossils. It may be a distinct species, but with the means at hand for comparison I am left in doubt on this point. Our figures *f*, *g* and *h*, of plate 5, fig. 3, represent this shell.

Genus STROPHOMENA, Rafinesque, 1827.

Some differences of opinion exist among Palæontologists and Conchologists in regard to what particular shell should be considered the typical form of this genus. Rafinesque's diagnosis was so brief and unsatisfactory, that it will apply almost equally well to any one of several genera, as now understood; and as he neither figured nor characterized any of the species, though he mentioned *S. rugosa* and others by name, it is difficult to determine, from his writings, for what particular group of shells he intended the name. Prof. Hall says he saw in Rafinesque's collection, purchased at the sale of his property after his death, by Dr. Poulson, a specimen of the common species *rhomboidalis* (=*Leptæna depressa* of several authors), accompanied by a label, on which was written, in Rafinesque's well-known hand-writing, the name *Strophomena rugosa;* and he therefore regards that as the type of the genus, though of course he admits that the older name *rhomboidalis* will have to be retained for the *species*. The fact that the name *rugosa* would so naturally suggest itself for this shell, to which it would be very applicable, certainly favors the conclusion that Rafinesque really had it before him when he wrote the name *Strophomena rugosa;* and hence that this form should be regarded as the type of the genus. Indeed, it had been given by several authors as the illustrative, or typical form of the genus, before the labeled specimen alluded to above had been especially noticed in Rafinesque's collection; and it has been so regarded by various others since.

Some, however, regarding the question respecting Rafinesque's type as being involved in doubt, have, in accordance with a very general, and usually good rule in such cases, appealed to the first authors who followed Rafinesque in the use of the name *Strophomena*, as settling the question in regard to the type. Defrance was, I believe, the first author that adopted the genus (in 1824); but, so far as I have been able to find, he only used it as Rafinesque did, that is, he neither figured nor described any of the species, but merely mentioned by name those that Rafinesque had mentioned. In 1825, however, Blainville adopted the genus, with a short diagnosis, and figured an illustrative example (doubtless sent to him from America) under Rafinesque's name *Strophomena rugosa*. But his figure clearly shows that the shell he had in view is a very different form from that found in Rafinesque's collection along with that name, and that it is by no means a rugose species. On the contrary, it is one of those resupinate forms, apparently undistinguishable from the common western species *S. planumbona*, to which species it almost certainly

belongs. Consequently, some authors would view this as the typical form of *Strophomena*, and not the geniculated species like *S. rhomboidalis*. Although at one time somewhat inclined to adopt this conclusion, it seems to me, on farther reflection, that if we use the name *Strophomena* at all as Rafinesque's genus, we ought to consider the only shell found in his collection with this name attached as the typical form of the group, especially as this type has been so generally figured as an illustrative example of the genus by subsequent authors.

If all authorities could agree that forms like *S. rhomboidalis* and *S. planumbona*, etc., belong to the same genus, it would, of course, be a matter of no material consequence which should be regarded as the type of the group. But some high authorities consider them generically distinct, while others would separate them sub-generically. But perhaps a majority, including some who have devoted much time and study to the investigation of the *Brachiopoda*, make no distinction whatever—or, in other words, include the whole under the genus *Strophomena*, without even a sub-generic separation.

At present I am rather inclined to the opinion that the Cincinnati species like *S. planumbona*, and most of the others here described, should be separated generically from the group including *S. rhomboidalis*, and placed under Pander's name *Hemipronites*.* As it is still an open question, however, in regard to which of these types should retain the older name *Strophomena*, and I have neither the time nor (at hand just now) the necessary collections to enter upon a general study of these and allied groups, I have concluded to view *S. rhomboidalis*, provisionally, as the type of the genus *Strophomena*, and to range the others under Pander's name *Hemipronites*, as a *sub-genus* under the same.

It may be proper, however, to state here, for the information of students not yet familiar with the difficulties of zoological nomenclature, that in case the *S. planumbona* group shall be finally separated *generically* from that including *S. rhomboidalis*, and the former shall take the name *Strophomena*, then the latter *may* have to take Dalman's name *Leptæna*, published in 1828. Unfortunately, in publishing the genus *Leptæna*, Dalman included in it *S. rhomboidalis* (under other specific names), along with species of *Productus*, and other types of *Strophomena* and *Leptæna*, as those genera are now usually understood. But his first species was the *S. rhomboidalis*, and consequently some authors view that as the typical form of *Leptæna*. If this conclusion should be adopted, it unfortunately

* *Streptorhynchus* of King was proposed in 1850 for Permian and Carboniferous forms, often having a very high area, and more or less distorted beak; but apparently agreeing, in all essential characters, with the type of *Hemipronites*.

requires still another important change of nomenclature—that is, that the group including such forms as *Leptæna sericea*, and now almost universally known under the name *Leptæna*, should take Pander's name *Plectambonites*, published in 1830. It seems to me, however, as already intimated, that it will be far better to avoid this perplexing swapping about of old familiar names, by considering *S. rhomboidalis* as the type of the genus *Strophomena* (as the facts stated seem to warrant), and then to place the other forms already referred to under Pander's name *Hemipronites*, either as a sub-genus under *Strophomena*, or as a separate and distinct genus.

Strophomena rhomboidalis, Wilckens (Sp.).

Plate 5, figs. 6 *a*, *b*, *c*, *d*, *e*.

Conchita rhomboidalis, Wilckens, 1769; Nachricht von seltenen Verst., p. 77, pl. viii., figs. 43 and 44.

Anomites rhomboidalis, Wahlenb., 1821; Nov. Acta Upsal, Vol. VIII., p. 65.

Producta depressa, Sowerby, 1823; Min. Conch., Vol. V., p. 86, pl. 459, fig. 3.

Producta rugosa, Hisinger, 1826; Act. R. Acad. Sci. Holm., p. 333; Deshayes, 1836, Lam. An. Syst., Vol. VII., p. 380.

Leptæna rugosa, and *L. depressa*, Dalman, 1828; Vet. Akad. Handl, pp. 106 and 107, pl. I, figs. 1 and 2; Kloden, 1834; Verst. Brandenb, p. 180; Hisinger, 1837, Leth. Succia, p. 69, pl. xx., figs. 2, 3, and others.

Strophomena rugosa, Brown, 1835; Lethaea Geog., p. 87, pl. ii., fig. 8; Von Buch, 1837, Ueber Detth., p. 70; also, 1840, Mem. Geol. Soc. Fr., Vol. IV., p. 220, pl. xii., fig. 24.

Leptæna depressa, J. de C. Sowerby, 1839; Silur. Syst., pp. 623 and 636, pl. xii., fig. 2, and of many others.

Leptæna tenuistriata, Sowerby, 1839; *ib.*, p. 636, pl. xxii., fig. 2 *a*; also of Hall, Salter, and others.

Strophomena depressa, Vanuxem, 1842; Geol. Report, Third Dist., N. Y., p. 79, fig. 5, and of others.

Orthis depressa, Portlock, 1843; Geol. Lond., p. 450; Quenstedt, 185, Handb., p. 488, pl. 32, fig. 20, and of others.

Leptæna (*Leptagonia*) *depressa*, McCoy, 1852; Brit. Pal. Foss., p. 248.

Strophomena rhomboidalis, Lindstrom, 1860; Goth. Brach., p. 371; Haswell, 1865, Sil. Form. Pentland Hill, p. 33, plate iii., fig. 3; Davidson, 1868, Trans. Geol. Soc. Glasgow, Pal. Ser., Vol. I., p. 16, pl. ii., figs. 17, 18; and 1871, Monogr. Brit. Fossil Brach. (Silurian), p. 281, pl. xxxix., figs. 1–21.*

Strophomena gibbosa, James, 1871; Cat. Lower Sil. Fossils, Cincinnati Group, p. 9.

This widely distributed shell is too familiar to geologists and collectors to require a detailed description. It seems desirable, however, that it

* For the long list of other references, see Mr. Davidson's Monographs of British Fossil *Brachiopoda*, from which most of the above have been taken.

should be illustrated and noticed here, in order that students may be apprised of the fact that it is one of the forms they may expect to meet with in the Cincinnati group, as well as in some more recent formations of Ohio. Its most marked characters are the strongly flattened and concentrically wrinkled visceral region of both of its valves, and the abrupt geniculation of the front and lateral margins of the same; the deflection being from below upward. The interior of its dorsal valve also has a very prominent ridge around the anterior and lateral regions bounding the visceral area. The general outline of the shell is usually more or less nearly semi-circular; but specimens have been referred to it by Mr. Davidson, in England, with a nearly transversely oblong outline, some of which also have a strongly trilobate front. The latter forms, however, have not, I believe, been observed in this country.

The specimens before me have the cardinal area narrow in both valves, but wider (higher) in the ventral, which has its inconspicuous beak provided with the usual minute perforation, and its triangular foramen closed, or nearly closed, by the bifid cardinal process of the other valve. The whole surface of both valves is ornamented by fine, even, closely arranged, radiating striæ, that most frequently increase by intercalation on the ventral valve, and by bifurcation on the dorsal; while crossing these, on both valves, well preserved specimens show, under a magnifier, extremely minute, regular, crowded, concentric striæ.

One of the largest Ohio specimens before me, from the upper part of the Cincinnati group, measures 0.84 inch, direct from beak to front, 1.30 inches in breadth, and 0.46 inch in convexity.

Widely different opinions prevail among geologists and palæontologists in regard to the geological range of this species. Mr. Davidson and many other high authorities believe that it ranges from the Lower Silurian into the Carboniferous; while others separate the specimens found at these extremes, and at some intermediate horizons, into several distinct species. Although not intending to express a decided opinion on this point, without having the necessary material at hand for comparison while preparing these remarks, it certainly seems to me that our specimens present no constant appreciable differences from Upper Silurian and Devonian forms generally referred to *S. rhomboidalis*, or *S. depressa*, as it has most generally been called in this country. Compared with Mr. Davidson's figures of British Silurian examples, the internal ridge around the line of deflection of the dorsal valve, in our specimens, differs from most of his figures, in not converging inward as it approaches the hinge, but, on the contrary, either approaches the hinge at right angles to the same, or curves outward. The specimens figured by

Mr. Davidson, however, differ much in this respect, while some of them do not differ materially from ours in this character.

Locality and position: As generally understood, this species has an almost world-wide geographical range, and, as already stated, a great vertical range, especially if the Carboniferous form is to be included as a variety. It occurs at various localities in the Trenton Limestone in New York and some of the neighboring States; also in the Clinton and Niagara groups, Lower Helderberg rocks, Schoharie grit and Corniferous limestone. In Ohio, it ranges from the lower part of the Cincinnati group, apparently into the Waverly group. I have no specimens from the Waverly group at hand at the moment of writing, for comparison, but speaking from memory, I can scarcely doubt the identity of specimens seen from that horizon. Among the localities where it has been found in the Cincinnati group, in Ohio, may be mentioned Cincinnati (50 feet above low water of the Ohio), and higher in the group in Butler and some of the adjoining counties. It also occurs at the same horizon at Madison, in Indiana, and in Kentucky, etc. A long list of other American and foreign localities might also be added, if desirable.

Sub-genus HEMIPRONITES, Pander.

(*Resupinate species.*)

Strophomena nutans, James.

Plate 6, fig. 1 *a* to *f*.

Strophomena nutans, James, 1871; Cat. Lower Sil. Fossils, Cincinnati Group, p. 9. Comp. *S. camerata* and *S. deltoidea*, Conrad; Palæont. N. Y., Vol. I., p. 31 A, figs. 2 and 3.

Shell under medium size, sub-trigonal, strongly concavo-convex, comparatively thick and strong; hinge about equaling the breadth of the valves; lateral margins usually somewhat straightened behind, where they meet the extremities of the hinge nearly at right angles, while anteriorly they converge to the middle of the front, which is prominent, and very narrowly rounded, or almost angular in outline.

Dorsal valve remarkably convex in the central or anterior central region, from which it rounds down abruptly to the lateral and anterior margins, and slopes strongly posteriorly, the anterior lateral slopes being usually somewhat compressed, so as to impart to the middle of the anterior region a degree of prominence, somewhat like a mesial ridge, near the margin; whole umbonal region flattened; area narrow, or sub-linear, and directed nearly backward; beak not distinct from the edge of the area. Interior with the bifid cardinal process short; sockets deep, sub-trigonal, and very oblique; socket-ridges rather prominent, thin, and continued obliquely forward and outward, with an inward

curve, so as to form the lateral margins of the muscular impressions, which are well defined, rather deep, strongly striated, and separated by a short, mesial ridge coming from the base of the cardinal process; while near the middle of the anterior edge of each, there is sometimes a little oblique prominence; central region, in front of the muscular impressions, sometimes showing four obscure parallel ridges running directly forward, and separated from each other by three shallow, narrow furrows, in the middle of each of which there is a raised line; traces of other smaller and more obscure ridges sometimes extend forward and laterally on each side of those described, while the whole internal surface is usually minutely granular.

Ventral valve nearly flat, with a backward slope in the umbonal region, and distinctly concave farther forward, in the anterior central region; while the anterior and lateral margins are abruptly curved downward parallel to those of the other valve; beak scarcely distinct from the margin of the area, which is of moderate height, flat, and extends the entire length of the hinge, with usually but little taper toward the lateral extremities; foramen rather broad trigonal, and covered above by the convex pseudo-deltidium, which is broadly and deeply sinuous on its inner edge, for the reception of the cardinal process, and a kind of pseudo-deltidium of the other valve, formed by the continuation of the socket plates. Interior with the anterior and lateral margins, geniculated so as to form a marginal ridge that is deeply and somewhat regularly furrowed across, while the ovarian spaces within this marginal ridge are more or less flattened, and sometimes granulated; hinge teeth moderately prominent, transversely sub-trigonal, and striated on their anterior and posterior faces; while from their inner bases the prominent dental ridges extend forward and curve together, so as to form a strongly elevated margin to the deep, sub-circular cavity for the reception of the muscular impressions; muscular cavity scarcely reaching the middle of the valve, usually with its rim slightly notched (not emarginated) at the middle of the front; while within its bottom it is provided with a slender mesial ridge, with the narrow adductor muscular scars on each side of it, and on the outside of these, most of the remaining space seems to be occupied by the striated scars of the divaricator muscles, there being only a very small notch-like impression close to the hinge tooth on each side, apparently left by the ventral adjustor muscles.

Surface of both valves ornamented by very fine, closely arranged, simple radiating striæ, that increase by intercalation, and are either nearly equal, or sometimes have every third, fourth or fifth one slightly larger than those between; while on well preserved specimens, very minute,

crowded, concentric striæ may be seen, by the aid of a strong magnifier, crossing the much larger radiating striæ.

Length of a mature specimen, 0.80 inch; breadth, 0.93 inch; convexity, 0.50 inch.

This species resembles some varieties of *S. deltoidea* and *S. camerata*, Conrad: but it seems to present too strongly marked external and internal differences to be referred to either. In convexity it appears to agree more nearly with the latter, but it shows no traces of the concentric ridges occupying the umbonal region of that form, and differs materially in its prominent sub-angular front, which imparts a nearly triangular form to the valves, instead of having the front broadly rounded. In this prominent sub-angular character of the middle of its front, it agrees more nearly with some varieties of *S. deltoidea*, but it is a greatly more convex shell, and, as already stated, shows no traces of the concentric ridges on its flattened umbonal region, generally so well marked on that shell; while the details of its internal characters also seem to differ, those of its dorsal valve being very similar to what we see in *S. filitexta*, from which the shell differs widely in nearly all other respects.

The strong concavo-convex, sub-trigonal general form, and the thickened internal ridge and geniculation of its ventral valve are marked features in this species.

Locality and position: Upper part of the Cincinnati group, in Butler, Warren and Clinton counties, Ohio. Mr. James's collection.

Strophomena planumbona, Hall.

Pl. 6, fig. 3 *a* to *h*.

? Strophomena rugosa, Blainville, 1825; Malacol., p. 513, pl. LIII., figs. 2 and 2 *a* (not of other authors).

Leptæna planumbona, Hall, 1847; Palæont. N. Y., Vol. 1, p. 112, pl. 31 B, fig. 4 *a, b, c, d, e*.

Strophomena planumbona, Hall, 1859; Regents' 12th State Cab. Report, p. 70; Geol. Report, Wisconsin (1862), p. 54, fig. 7.

Shell rather small, or scarcely attaining a medium size, concavo-convex, semi-oval, or more than semicircular in outline; hinge line generally a little longer than the breadth of the valves at any point farther forward; lateral extremities, in most examples, somewhat less than rectangular, or sometimes rather acute, more or less compressed and deflected; lateral margins a little contracted posteriorly, and rounding to the front, which forms a regular semicircular curve.

Dorsal valve flat in the umbonal region, and rather strongly and

evenly convex in the central and anterior regions, from which it rounds off abruptly to the front and lateral margins; beak very small, or not distinct from the edge of the narrow or sublinear area, which is inclined nearly directly backward, but not incurved. Interior showing the cardinal process to be small, depressed, divided to its base into two diverging tooth-like parts, a little flattened on their posterior faces, and directed very obliquely forward and outward; socket ridges short and oblique; mesial ridge low, extending but a little distance forward; while the space between it and the socket ridge, on each side, is occupied by a moderately distinct muscular scar.

Ventral valve broadly and rather deeply concave in the central and anterior regions, and slightly convex at the beak, which is very small, abruptly pointed, scarcely projecting beyond the edge of the area, and usually minutely perforated; area moderately high, extending the whole length of the hinge, generally but little sloping laterally, flattened and inclined more or less backward; foramen closed by a prominent, rounded pseudo-deltidium, that is transversely striated, and rather broadly sinuous on its inner edge, for the reception of the cardinal process of the other valve. Interior showing hinge teeth to be well developed, trigonal, and striated on their posterior sides; while from their inner bases the dental laminæ extend forward so as nearly to encircle the usual saucer-shaped depression for the muscular scars, which is sometimes divided by a small, linear mesial ridge; cardinal margin prominent and sharp within, on each side of the hinge teeth; anterior and lateral regions more or less thickened within, and roughened by the crossing of the vascular markings, which are scarcely visible on any part within this zone.

Surface of both valves ornamented by numerous fine, closely crowded, radiating striæ, that are often alternately a little larger and smaller, or on some parts, with several of the smaller ones between each two of the larger; the smaller being always shorter than the larger, or ending at various distances between the free margins and the beaks, without coalescing with those between which they are intercalated. Striæ and furrows minutely crenulated by extremely small, very regular, closely arranged, concentric lines, invisible without the aid of a magnifier; a few sub-imbricating marks of growth are likewise sometimes seen near the free margins.

Length of a medium sized specimen, 0.73 inch; breadth, 0.93 inch; convexity, 0.24 inch; number of striæ in the space of 0.10 inch near the middle of the front margin, from 5 to 8; the greater number being where smaller ones are intercalated between the larger.

This is the shell that has always been identified by Western geologists with *S. planumbona* of Hall, and it agrees well with his description of that species; though it differs materially from his figures 4 *a* and 4 *b*, cited above, in presenting scarcely any traces of the strong, rounded, concentric folds shown on the same. As no traces, however, of these folds are represented on his profile, figure 4 *e*, of the same plate, which would certainly show them in relief if they exist as represented by the other figures, and nothing is said in the description about concentric ridges or folds (which would be an unaccountable omission if the shell really presents such a character), while no shell agreeing with these figures in these respects is known to collectors from the localities mentioned in the West, we may reasonably infer that it is due to an error in the figures that they are made to represent such strong concentric ridges. If this is not so, the shell here represented would agree much more nearly with *S. deflecta* of Conrad, as illustrated on the same plate of the New York Palæontology, to which it certainly seems to be very closely related.

In size, and some other respects, this shell resembles the last, but it differs materially in being much more compressed, and in not presenting the peculiar trigonal form imparted to that shell by the prominent, subangular middle of its anterior margin. There are also well defined internal differences between the two shells.

Locality and position: Upper part Cincinnati group, in Clinton and Preble counties, Ohio, and Richmond and neighboring parts of Indiana. Prof. Hall also mentions Madison, Indiana; Maysville, Kentucky; and Cincinnati, Ohio. It does not occur at Cincinnati, however, but seems to be confined to a higher horizon.

Strophomena plicata, James.

Pl. 6, fig. 4 *a* to *h*.

Strophomena plicata, James, 1871; Cat. Lower Sil. Fossils, Cincinnati Group, p. 9.
Compare *Lept. subtenta* (Conr. MS.), Hall, 1847; Palæont. N. Y., Vol. I., p. 115, pl. XXXI. B, fig. 9 *a*, *b*; and *Lept. planumbona*, Hall, 1847, Ib., p. 114, pl. XXXI. B, fig. 7 *a*, *b*, *c*, *d*.

This form agrees so nearly with that last described, that a formal detailed description would be, with the exception of a few characters, almost an exact repetition of the same words. It will, therefore, be sufficient to point out the few characters in which it differs. In the first place, it attains a somewhat larger size, and a rather more robust appearance; while its lateral extremities are often more acutely angular, and marked by a few wrinkles directed very obliquely outward and backward. It is worthy of note, however, that some of the specimens from the original locality, agreeing in all other respects, do not show these wrinkles, while

others are less extended on the hinge line. The largest specimens also seem to have the striæ slightly more distinct than in the last, and rather more sharply crenated, though they are still variable in this character. In all internal characters the two forms appear to agree quite closely.

From this close agreement, I have doubts whether this form should be considered as more than a variety of the form usually referred to *S. planumbona*. In most of its characters it would also seem to be closely allied to *S. subtenta* of Conrad, as illustrated in the New York Palæontology, from which it only appears to differ externally, in the more acutely angular and produced character of its lateral extremities, as seen in its more typical examples. Otherwise, it agrees exactly in form and surface markings, even to the oblique wrinkles on its lateral extremities.

In this oblique direction of these wrinkles, it agrees much better with the figure first published under the name *S. subtenta*, than any of the specimens yet sent to me from the West with that name attached; all of which latter have the wrinkles ranging at right angles to the hinge margin. It is worthy of note, however, in this connection, that the published figure alluded to, under Mr. Conrad's name, was from Oxford, Ohio; while Mr. Conrad's original type, which has not yet been published, came from the Trenton rocks of New York. Consequently, it is possible that the shell figured in the New York Report may be an individual of the form here under consideration, with its lateral extremities less than usually extended, or worn or broken away, and yet differing specifically from Mr. Conrad's New York type.

It will also be noticed that this shell closely resembles certain forms of *S. filitexta*, both in its external and internal characters; large individuals, with the oblique wrinkles obsolete, or nearly so, being very similar to medium sized specimens of that species. From these facts it seems not very improbable that a thorough comparison of more extensive collections of these shells may bring to light good and sufficient reasons for uniting this form with one of those mentioned. For the present, however, I prefer to keep it separate, provisionally, under Mr. James's name, *S. plicata*.

Locality and position: Upper part of the Cincinnati group, near the base of the hills at Richmond, Indiana, where it is very abundant, and found in a beautiful state of preservation. It also occurs at other localities of that region, at the same horizon, in Ohio and Indiana.

Strophomena plano-convexa, Hall.

Pl. 2, fig. 2 *a* to *h*.

Strophomena plano-convexa, Hall, 1847; Palæont. N. Y., Vol. I., p. 114, pl. XXXI. B, fig. 7

This is another form so near *S. planumbona*, as to be readily characterized by pointing out the characters in which it differs. In the first place,

it is rather constantly, though not always, wider in proportion to length, sometimes attains a rather larger size, and always differs in having the ventral valve nearly flat, or but slightly concave, instead of being distinctly so; while its dorsal valve is usually, but not always, a little less convex. The area of its ventral valve is likewise, in most examples, proportionally rather lower, and more tapering to the lateral extremities. Its surface striæ are perceptibly coarser than in *planumbona*, or any of the other allied species of this horizon, and seem not to be nearly so distinctly crenated, particularly as the form described under the name *plicata;* while they more frequently increase in number by bifurcation than in *plicata* or *planumbona*, instead of by intercalation, and the smaller ones sooner attain the size of the others, so that the whole present a more uniform size. The perforation of its beak is more constant, and rather larger than in any of the others mentioned. It can be readily distinguished from all the other forms by the above mentioned external characters; while internally it seems always to want the thickened and roughened zone around the anterior and later margins, seen in *S. nutans*, *S. planumbona*, *S. plicata*, and the other allied resupinate forms of this region.

Locality and position: Cincinnati group, at a horizon of about 300 feet above the Ohio, at Cincinnati. It also occurs at about the same horizon at many places in Indiana, Kentucky, Wisconsin, etc. Mr. James's, Mr. Shaffer's, Mr. Dyer's, Mr. Miller's, and other collections at Cincinnati.

Strophomena filitexta, Hall.

Pl. 6, fig. 5 *a*, *b*, *c*, *d*.

Leptæna filitexta, Hall, 1847; Palæont. N. Y., Vol. I., p. 111, pl. XXXI. B, figs. 3, *a*, *b*, *c*, *d*, *e*, *f*.

Strophomena filitexta, Hall, 1859; Regents' 12th Ann. State Cab. Report, p. 70.

? *Strophomena neglecta*, James, 1871; Cat. Lower Sil. Fossils of Cincinnati Group, p .9.

Shell attaining a moderately large size, semi-oval, the length being always less than the breadth; hinge line generally greater than the breadth at any point farther forward; lateral extremities usually somewhat acutely angular, and deflected; lateral margins a little sinuous posteriorly, and rounding to the semicircular front.

Dorsal valve flat in the umbonal region, and evenly convex in the anterior central and lateral portions, and curving downward around the front and lateral margins; area narrow, or nearly linear, and directed obliquely backward and upward; beak not distinct from the margin of the area.

Ventral valve nearly flat, or slightly convex in the umbonal region, and broadly and deeply concave in all the central and anterior central parts,

but curving upward around the front and lateral margins nearly parallel to the free margins of the other valve; cardinal area of moderate height, extending the whole length of the hinge, but sloping rather distinctly from the beaks laterally, flat and directed nearly at right angles to that of the other valve; beak very small, and only projecting slightly beyond the margin of the area; foramen closed by the usual convex pseudo-deltidium, which is deeply sinuous on its inner margin, for the reception of the cardinal process of the other valve. Interior with cardinal edge but slightly prominent; hinge teeth sub-trigonal, oblique, and but moderately developed; dental ridges prominent, strong, and encircling a rather large, deep, saucer-shaped cavity, one-third to one-half the length of the valve, and marked within by an obscure central ridge, and on each side of this by rather strong radiating furrows; anterior and lateral margins a little thickened within, and divided by the crossing, apparently, of the vascular markings, into short, obscure ridges; entire internal surface sometimes showing, under a magnifier, a very minute, obscurely granular appearance.

Surface of both valves ornamented by numerous fine, sub-equal, crowded, and rounded, radiating striæ, that increase by intercalation, there being usually slightly larger ones at regular intervals, with three or four smaller ones between, on all the central regions of the valves, only the former of which extend nearly or quite to the beaks; before reaching the anterior and lateral margins, all of the smaller, excepting the shortest, increase nearly or quite to the size of the largest; crossing the whole, there may be seen, by the aid of a magnifier, numerous much finer, closely crowded, concentric striæ, and sometimes a few obscure, distant, stronger marks of growth.

Length of a mature specimen, 1.35 inches; breadth, 1.82 inches; convexity, about 0.36 inch.

I am not entirely sure that any of the specimens examined, showing the interior of the dorsal valve, belong to this species; those *believed* to belong to it, yet examined, having the exterior either firmly imbedded in the matrix, or incrusted over by a growth of corals. These have the cardinal process, as in other allied forms, short and divided into two low diverging parts, directed obliquely forward and outward, and flattened or a little concave on their posterior sides; while the socket ridges on each side are very short and oblique. In the bottom of the valve three low, nearly parallel ridges start forward, from near the base of the cardinal process, the middle one of which is shortest, while the lateral extend to, or a little beyond, the middle of the valve. Two others also originate

behind the middle, between these three, and extend forward parallel to each other, farther than any of the others. Between these four longer ridges, three very slender, much smaller raised lines, may also sometimes be seen, while a large area of the central region of the valve, including the ridges mentioned, and a considerable space on each side of them, is occupied by small, but distinct granulations, that show a tendency to arrange themselves into radiating lines.

This species seems to be quite different, and readily distinguished, from any of those mentioned before it, not only by its larger size, but by its internal characters. I am left in some doubt, however, whether the form called *S. neglecta*, in Mr. James's list, is the same species as the *filitexta*, not having seen specimens showing its internal characters. Most of Mr. James's type specimens of that shell show little or no difference of form from those here referred to *S. filitexta*. One of them, however, is much more elongated on the hinge line, and evidently had more acutely angular lateral extremities. They all, likewise, have nearly the same sized striæ; but the striæ are much more distinctly crenated by the crossing of their more sharply defined, and rather more distant concentric microscopic lines. Unless these shells may present some internal differences, however, I should think them probably not specifically distinct from the other western shells usually referred to *S. filitexta*.

Locality and position: The typical specimens of this species were from the Trenton Limestone of New York. But Prof. Hall mentions seeing it from the same horizon in Ohio; though the localities from which it was obtained in the latter State doubtless belong to the Cincinnati group, which he at that time referred to the horizon of the Trenton. The specimens here under consideration came from the upper part of the Cincinnati group, in Clinton county, Ohio.

Strophomena sulcata, de Verneuil.*

Plate 5, figs. 4 *a*, *b*, *c*, *d*, *e*.

Leptæna sulcata, de Verneuil, 1848; Bull. Geol. Soc. Fr., Vol. V., p. 350.
? Strophomena sinuata, Emmons, 1855; Am. Geol., Vol. I., p. 199, fig. 61 (not James, 1871).
Strophomena sulcata, James, 1871; Cat. Fossils Cincinnati Group, p. 9.

Shell small, more than semicircular in outline, moderately convex, sub-equivalve, the dorsalvalve being more convex at the middle of the front, and the ventral in the umbonal region; hinge line equaling the greatest breadth, lateral margins intersecting the hinge nearly at right angles, and rounding to the front, which is regularly rounded, or sometimes faintly sinuous in the middle. Dorsal valve flat at the umbo, and

* This and the first of the following species are peculiar in form, and perhaps belong to a different section from any of the others here described.

raised into a rounded, more or less prominent mesial elevation at the front; beak scarcely distinct from the cardinal margin, which is provided with a very narrow area. Ventral valve a little convex at the umbo, and impressed, or bent so as to form a shallow mesial sinus at the front, that rarely extends back to the middle, provided with a well-defined, rather high area, that is flat and a little inclined back over the hinge; foramen closed by a triangular, convex, pseudo-deltidium; beak not projecting or incurved; but inclined backward with the area, and perforated by a minute, circular aperture at the apex. Surface of both valves ornamented by rather fine, more or less bifurcating, radiating striæ, crossed by rather distinct marks, and finer striæ of growth.

Length of a large specimen, 0.63 inch; breadth, 0.84 inch; convexity, 0.20 inch.

Although this is a common shell, specimens showing the interior are very rarely found, the valves nearly always being united. A single separate dorsal valve in Mr. James's collection, however, shows the hinge, and a little of the interior. In this the cardinal process is seen to be short, and deeply bifid, with very diverging socket ridges on each side, and a small central ridge extending forward from its base. The sockets for the teeth of the other valve are well defined, and rather wide apart. The specimen is not in a condition to show the scars of the interior. None of the specimens I have yet seen show the hinge or interior of the ventral valve.

This is a well marked species, readily distinguished from all the other known forms in our rocks, excepting the next, which it nearly resembles.

I am in some doubt whether it was this, or the following type, that was figured and described by Dr. Emmons, under the name *S. sinuata*, in his American Geology. His figure certainly agrees better with this than with the next, especially in convexity, as shown by his profile view; while his other figure shows the stronger concentric markings and finer striæ of this form. On the other hand, he gives Cincinnati as the locality of his type, at which place the *sulcata* does not occur; while the *sinuata* of James does occur at, or near, that city. The *S. sulcata*, however, being a common species, and in the cabinets of all of the Cincinnati geologists, it is quite possible that Dr. Emmons might have received it from some person living there, and supposed that it was found at that locality.

Locality and position: Butler, Warren, Clinton and Preble counties, Ohio; also at Richmond and other localities in Indiana, always in the upper part of the Cincinnati group. It is not found at Cincinnati, the highest beds there being, apparently, below its proper horizon. I am under obligations to Mr. James and Mr. Shaffer for the specimens studied, and for a knowledge of its geological horizon.

Strophomena sinuata, James.

Plate 5, figs. 5 *a, b, c, d, e, f.*

Strophomena sinuata, James, 1871; Catalogue Fossils Cincinnati Group, p. 9 (not of Emmons, 1855?).

Shell semicircular, or forming rather more than a semicircle, moderately convex, with valves nearly equal, the dorsal being most convex in the central and anterior regions, and the ventral near the umbo; hinge nearly or quite equaling the greatest breadth; lateral margins forming more or less nearly right angles with the hinge line, or sometimes rounding a little to the same, and rounding regularly to the front, which forms a semicircular curve, with rarely a slight sinuosity at the middle.

Dorsal valve flat at the beak, which is not distinct from the cardinal margin, usually a little raised in the middle at the front, so as to form a low, broad, undefined mesial prominence; cardinal area narrow and inclined backward; interior with a low, small, deeply bipartite cardinal process, from which diverge three small ridges, the two lateral of which extend obliquely outward to form the margins of the rather well defined sockets for the reception of the teeth of the other valve, while the third ridge is central, and extends a short distance forward; muscular scars not visible in any specimen examined.

Ventral valve moderately convex at the umbo, which is not very prominent or arched, and has a minute perforation at the apex; front with usually a broad, shallow, undefined depression; lateral regions more or less nearly flat; cardinal area well developed, tapering to the lateral extremities, flat, and inclined more or less obliquely backward; foramen closed by a prominent, triangular deltidium; interior showing small, somewhat saucer-shaped cavity, formed by the low, sharp dental laminæ, extending forward from the inner side of the rather well-developed oblique cardinal teeth, and curving a little toward each other, without meeting at their inner ends; muscular scars not visible in any specimens examined.

Surface of both valves ornamented with rather coarse radiating striæ, most of which bifurcate once or oftener, while occasionally a shorter one is intercalated between two longer; crossing the whole, occasional small marks of growth, and finer, but obscure, concentric striæ may be seen by the aid of a lens, on well preserved specimens.

Length of a rather large specimen, 0.65 inch; breadth, 0.88 inch; convexity, 0.30 inch.

This form is so nearly like the last, in nearly all its known characters, that I would more decidedly question the propriety of separating them, if it were not for the fact that they occur, as I am informed by Mr. James and the other geologists of Cincinnati, at horizons separated by about 300 feet of strata, in which neither form is found. About the only essential differences between them are the following: In the first place, *S. sulcata* has the sinus in the front of its ventral valve nearly always deeper (sometimes decidedly so), and the corresponding elevation of the other valve more prominent, while its striæ are almost always a shade finer than in the form under consideration. It is also generally a little less compressed, particularly around the free margins, which usually show stronger sub-imbricating marks of growth.

These differences, although not striking, are readily perceptible in almost all the varieties of each, so much so, indeed, that the two shells are never confounded by collectors. Still, the analogous *S. antiquata* of Sowerby, as illustrated by Mr. Davidson, might apparently be readily separated on more strongly marked characters, into several species.

Locality and position: Near Cincinnati, Ohio, in the Cincinnati group, 350 feet above low water of the Ohio.

(*Non-resupinate species.*)

Strophomena alternata (Conr.), Emmons.

Plate 7, figs. 1 *a* to *g*.

Leptæna alternata, Conrad, 1838; Ann. Geol. Rep. N. Y., p. 115 (without figure or description); ?de Verneuil, 1845, Geol. Russia and Ural Mts., part Palæont., p. 225, pl. 14, figs. 6 *a*, *b;* Hall, 1847, Palæont. N. Y., Vol. 1, p. 102 and 286, pl. XXXI., figs. 1 *a–n*, XXXI. A, figs. 1 *a–h*, and pl. 79, figs. 2 *a* to *l*.

Strophomena alternata, Conrad, 1839; Ann. Geol. Report, N. Y., p. 63; also *Ib.*, 1840, p. 201, and 1841, p. 37 (all without fig. or description); Emmons, 1842, Geol. Rep. N. Y., 2d Dist., p. 195, fig. 3; Hall, 1859, Regents' 12th Ann. State Cab. Nat. Hist. Report, p. 70.

Strophomena nasuta, Conrad, 1842; Jour. Acad. Nat. Sci., Philad., Vol. VIII., p. 260; Emmons, 1845, Geol. Report, p. 403, fig. 3.

Leptæna alternistriata, Hall, 1847; Palæont. N. Y., Vol. I., p. 109, pl. XXXI. B, fig. 1 *a*, *b*, *c*.

Strophomena alternistriata, Hall, 1859; Regents' 12th Ann. State Cab. Nat. Hist. Report, p. 70.

Shell attaining a large size, semi-oval, the breadth being nearly always greater than the length, but varying from about equal to the latter to the proportions of near nine to seven; hinge line as long as the breadth of

the valves at any point farther forward, or somewhat longer; lateral extremities rectangular, or a little more or less than rectangular, sometimes compressed and moderately deflected; lateral margins straight, a little convex, or slightly sinuous posteriorly, and rounding forward to the front, which is semicircular in outline, or sometimes so prominent and narrowly rounded in the middle as to impart a sub-trigonal form to the general outline of the valves.

Dorsal valve flattened in the umbonal and cardinal regions; and gently, or more or less strongly concave in the central and anterior portions, and curved upward around the anterior and lateral margins; beak small, but projecting slightly beyond the edge of the area, which is very narrow, or sub-linear, and directed nearly backward. Interior with cardinal process strong, directed obliquely forward, with its two divisions distinctly diverging, and flattened and longitudinally striated on their posterior faces; sockets for the reception of the teeth of the other valve rather well defined; socket ridges very small, and uniting behind the cardinal process to form a kind of false deltidium; muscular scars comparatively small, but deeply impressed near the cardinal process on each side of a small, short, mesial ridge, and nearly surrounded by a low obtuse ridge formed by the thickening of the adjacent internal surface of the valve; anterior and lateral margins more or less thickened and geniculated within (especially in adult shells), the thickened zone being transversely furrowed, and sometimes granular, while outside of it the immediate edge of the valve is suddenly flattened, and minutely striated and granulated.

Ventral valve a little convex at the umbo, but generally much compressed over the whole visceral region, in the adult (which includes the whole surface of the young and half-grown shell), but becoming more convex (sometimes strongly so) anteriorly, or anterio-centrally and laterally, and thence more or less curved up to the anterior and lateral margins; area of moderate height, flat, and directed obliquely backward nearly at right angles to that of the other valve; beak very small, scarcely distinct from the margin of the area, and minutely perforated; foramen broadly triangular, and arched over above by the pseudo-deltidium, which is very deeply sinuous on its inner edge, the sinus being nearly or quite closed by the dental process and pseudo-deltidium of the other valve.

Interior with cardinal margin somewhat carinate within; hinge teeth moderately prominent, remote, and widely divergent; dental ridges obscure, and extending obliquely outward and forward, but not produced or curving to surround a saucer-shaped cavity for the muscular scars;

scars of adductor muscles narrow, long and closely approximated, or almost in contact; those of cardinal muscles on each side very large, fan-shaped, but shallow, separated sometimes by a small ridge in advance of the adductor scars, and marked by radiating furrows and ridges; while the anterior and lateral regions are usually marked by striæ and scattering granules.

Surface of both valves ornamented by numerous radiating striæ, that increase in number, on the ventral valve, mainly by intercalation, and are usually arranged with one to six or eight smaller and shorter ones between each two larger and more prominent ones, the largest one of which often occupies the mesial line; while on the dorsal valve they more frequently increase by division, and are generally of more uniform small size. On well preserved specimens all the radiating lines are crossed by numerous very minute, regular, closely arranged concentric striæ, that are invisible without the aid of a magnifier; a few moderately distinct, sub-imbricating marks are also often seen near the free margins of adult shells.

Length of a rather large specimen (of medium convexity), 1.52 inches; breadth, 1.84 inches; convexity, 0.36 inch.

This shell varies considerably in convexity, and in the nature of its striæ, as well as in outline, etc.; and these dffferences have been sometimes considered to indicate several distinct species. It seems to me, however, that there are so many gradations connecting these different forms, that they can scarcely be regarded as more than varieties. Though, after all, it is to a considerable extent a matter of fancy whether such differences as characterize at least some of these, should be considered specific, or as only distinguishing varieties. The following differences of form and other characters may be observed among the specimens here included under this species:

1. *S. alternata*, proper.—Viewing Dr. Emmons' figure (the first ever published of the species) as representing the typical form, it may be briefly characterized as semi-oval, and rather depressed, with nearly rectangular lateral extremities, a regularly rounded front, and alternately larger and smaller surface striæ.
2. *Var. nasuta*, Con.—Sub-trigonal in outline, usually smaller and more gibbous than the typical form, with a more or less prominent obtuse, undefined mesial ridge, and generally a larger mesial striæ, on the ventral valve, the ridge being continued to the middle of the front, to which it usually imparts a narrowly rounded or sub-angular outline; ventral valve often becoming very convex, and the dorsal very concave in the anterior central and anterior lateral regions, from which they are both strongly curved upward to the anterior and anterior lateral margins. (See pl. 7, figs. 2 *a* to *c*.)

3. *Var. alternistriata*, Hall.—Differing very little from the typical form. Was separated mainly upon its supposed greater proportional breadth, and the more uniform size of the striæ of its dorsal valve. This uniform character of the striæ of the dorsal valve, however, is by no means confined to this variety of form; while even among the specimens figured by Prof. Hall as true *alternata*, some are more extended laterally than the typical specimen of *alternistriata*.
4. *Var. loxorhytis*, Meek.—Attains a large size, moderately convex antero-centrally, or rather depressed; much extended on the hinge line, with lateral extremities acutely angular, flattened, and scarcely deflected; area very narrow; both valves marked near the cardinal margin, toward the lateral extremities, by six to eight distinct, very oblique wrinkles on each side.
5. *Var. fracta*, Meek.—Very thin and fragile, smaller than the typical form, much compressed, decidedly semi-oval, the length equaling, or slightly exceeding, the breadth; lateral extremities rectangular, and not deflected; lateral margins generally straight or a little convex in outline behind, and rounding forward to the regularly rounded front; surface as in the typical form, excepting that there are usually more strongly marked imbricating laminæ of growth around near the free margins; interior of dorsal valve with muscular scars removed proportionally farther forward from the cardinal process than in the typical and other varieties. (See pl. 7, figs. 3 *a* to *e*.)

Of these five varieties, the last two seem to be the most marked. I have not seen any specimens that I could be sure belonged to the variety *loxorhytis*, showing the interior; but its much extended and obliquely wrinkled lateral extremities give it a peculiar appearance. The last variety (*fracta*) occurs in great numbers together, and is always very thin, distinctly compressed, and very narrow in proportion to its length. Although smaller than most of the other varieties, its strongly marked laminæ of growth near the free margins, and the uniformity of size observed among the specimens, seem to indicate that it is not a young shell; and the difference in the position of its muscular scars, mentioned above, seems to be constant. My attention was called to this latter form by S. A. Miller, Esq., of Cincinnati, who noticed it in some remarks before the Cincinnati Society of Natural History, during the winter of 1872, without proposing a name for it.

Locality and position: *Strophomena alternata* has an extensive vertical and horizontal range in the Lower Silurian rocks of this country, being found in the Trenton limestone of New York, Wisconsin, Tennessee and other States, as well as in Canada. It also occurs in the Cincinnati group, in Ohio, Indiana, Kentucky, Tennessee, New York, Canada, etc. In Ohio, none of its varieties occur much below the horizon of the tops of the hills at Cincinnati; but they nearly all, excepting perhaps the varieties *fracta*, *nasuta* and *loxorhytis*, range through most of the beds of the group above that horizon in Ohio. It has also been identified in Russia.

Genus ORTHIS, Dalman, 1828.

(Kongl. Vet. Acad., Handl., p. 96.)

(*Resupinate species.*)

Orthis retrorsa, Salter?

Plate 11, figs. 7 *a*, *b*, *c*, *d*, *e*.

Orthis retrorsa, Salter, 1858; Mem. Geol. Survey Great Britain, Vol. 2, p. 373, pl. 27, figs. 3 and 4; Billings, 1862, New Species Lower Silurian Fossils, p. 136, figs. 112 and 113, and Palæoz. Fossils, Vol. (1865) 1, same p. and figures.

Orthis Kennicotti, McChesney; Descrip. New Sp. Fossils from the Palæozoic Rocks of the Western States, p. 78, dated 1861.

Orthis Carleyi, Hall, 1861; Regents' 13th State Cab. N. Hist. Report, p. 120, with woodcut.

Orthis porcata, Davidson (pars), 1871; Monogr. Brit. Foss. Brach. (Silurian), p. 250, (McCoy? 1843).

Shell attaining a medium size, varying from transversely sub-oval to truncato-sub-oval, or sub-quadrate, the length being about four-fifths its breadth; hinge line shorter than the greatest breadth of the valves, or about equaling their length, with its lateral extremities abruptly rounded, or very obtusely sub-angular; lateral margins more or less convex in outline, and rounding to the front, which is either regularly rounded, or somewhat straightened along the middle; valves decidedly unequal, or concavo-convex.

Dorsal valve evenly, and sometimes rather distinctly convex, the most prominent part being near, or a little behind the middle, with the anterior and lateral slopes, particularly the anterior, more gradual than the posterior; umbonal convexity projecting a little beyond the hinge; beak incurved; area of moderate height, but with its sharp margins sloping off to nothing near the extremities of the hinge, more or less strongly incurved, so as sometimes to stand at right angles to the plane of the valves; foramen broad-triangular. Interior unknown.

Ventral valve convex at the point of the beak, and thence sloping toward the lateral and anterior margins; the anterior central, and sometimes the lateral regions, being more or less concave; beak obtuse, or abruptly pointed, and strongly inclined forward; cardinal area broad-triangular, well defined, flat, and so distinctly inclined forward as to place the apex of the beak some distance in front of the hinge margin; foramen narrow-triangular, being often a little higher than wide, and extending to the apex of the beak.

Interior with muscular cavity rather deep, distinctly quadrangular,

scarcely reaching the middle of the valve, and sharply defined by a raised margin, which is perfectly straight and uninterrupted across the front;* while its lateral margins are each waved a little outward along the middle, to make room, as it were, for the scars of the ventral adjustor muscles, which are moderately distinct from those of the longer triangular divaricators; scars of the adductor muscles well defined, and occupying a narrow sub-cordate depression, which tapers gradually forward to an acute extremity between the anterior ends of the divaricator scars. Hinge teeth apparently rather small and weak. Vascular markings consisting of two principal trunks, starting from the anterior lateral angles of the muscular cavity, and each immediately dividing so as to send one main branch obliquely outward and backward, with more or less sub-divisions; and another forward with an inward curve, and also giving off more or less sub-divisions on the anterior lateral side.

Surface ornamented by rather coarse, rounded, radiating striæ, some of which, on the ventral valve, are entirely simple, and others bifurcate once or twice; while on the dorsal, they increase in number by the intercalation of shorter ones between the longer; there being, on a moderate-sized adult shell, about three series of the intercalated ones, the longest of which nearly reach the beak, and soon become as large as the largest, and between these there are a few very short, small ones, near the free margins, and a few others of intermediate length and thickness. A few rather distinct imbricating marks of growth are usually seen near the free margins of adult specimens; while under a magnifier, minute, concentric lines may be seen crossing the striæ and interspaces, and on protected parts of the surface a strong magnifier also shows very minute asperities, regularly arranged, and having the appearance of minute, hollow spine-bases, that sometimes leave minute pits when entirely worn off.

Breadth of a moderately large specimen, 1.17 inches; length, 0.95 inch; convexity, 0.47 inch.

This is a very well marked species, that may be distinguished at a glance, by its external characters alone, from all of our other large Lower Silurian forms, particularly by the peculiar character of having the flat, broadly triangular area of the ventral valve so strongly inclined forward

* Since this was written I have received from Mr. Dyer another specimen of this valve, of larger size, showing the anterior side of the muscular cavity to be deeply emarginate in the middle (see fig. 7 *d*, of plate 11); thus showing that this species either varies considerably in this character, or that there are two species confounded under the one name in the West.

as to place the beak of this valve some distance in front of the hinge line. It is with considerable doubt that I have adopted the conclusion, rather generally maintained, that this form is the same as that described by Mr. Salter, though it may be so. It certainly resembles his figure quite closely; but if the shell described by him is only a variety of *O. porcata*, as is believed by the best English authorities, the fact that we do not find the American form shading into any shell agreeing with *O. porcata*, would seem to indicate that it is either distinct from *O. retrorsa*, or that the latter can scarcely be a mere variety of *O. porcata*. We have shells here, such as *O. sinuata* and *O. occidentalis*, that represent *O. porcata*, but the form under consideration is clearly and constantly distinct from these.

Locality and position: At or above the middle of the Cincinnati group of the Lower Silurian. In Southern Ohio, Prof. Orton informs me that the vertical range of this shell is restricted to a thin bed of only a foot or so in thickness. He found it, however, at Madison, Indiana, at a higher horizon in the same series. Mr. Billings refers to *O. retrorsa*, a smaller shell, found in the same series near Ottawa, Bellville, etc., in Canada. Several authors give Cincinnati as the locality from which they obtained this species.

Orthis subquadrata, Hall.

Plate 9, figs. 2 *b* to *g*.

Orthis subquadrata, Hall; Palæont. N. Y., Vol. I., p. 126, pl. XXXII. A, figs. 1 *a–o;* and in Wisconsin Report, 1862, p. 54, figs. 1 and 2.

Shell attaining about a medium size, rather distinctly resupinate, somewhat wider than long, subquadrate in general outline; moderately convex; cardinal margin shorter than the breadth of the valves, and rounding abruptly at the extremities into the lateral margins, which round and converge forward; front a little sinuous or straightened at the middle.

Dorsal valve more convex than the other, its most prominent part being near the middle; mesial sinus small, and rather shallow, sometimes continued back nearly to the umbo, or in other instances scarcely more than reaching the middle; beak very short, or little distinct from the edge of the area, and more or less arched; area narrow, directed obliquely backward and downward. Interior with scars of the adductor muscles moderately distinct, the posterior pair being situated close back under the brachial processes, one on each side of a well defined rounded ridge, that becomes suddenly smaller between the anterior pair; cardinal process rhombic sub-conical, moderately prominent, and having its posterior side marked by deeply impressed divaricating striæ; sockets well

defined; brachial processes rather strong, and directed obliquely forward and laterally; internal surface, excepting the radiately striated front and lateral margins, nearly smooth.

Ventral valve a little convex at the umbo, and flat, or slightly concave, between the umbo and the front and lateral margins, but sometimes having a low, very obscure mesial elevation toward the front; beak small, and very short, or scarcely equaling that of the other valve, arched at the apex, but not strongly incurved; area about twice as high as that of the other valve, well defined, tapering rather rapidly toward the lateral extremities, arched with the beak, and directed backward and downward at decidedly less than a right angle to that of the other valve; foramen broad-triangular, and partly occupied by the cardinal process of the other valve. Interior with muscular scars occupying a rather deep, bilobate impression extending nearly or quite to the middle of the valve, and usually defined by a low ridge most distinct on each side; scars of adductor muscles small, separated by a mere trace of a raised line; those of the divaricator muscles of moderate size, longitudinally striated, and having their narrowed posterior ends extending backward nearly to a small, triangular, transversely striated space occupying the interior of the beak; those of the ventral adjustor muscles smaller and shorter than the divaricators, and situated nearly under the hinge teeth, which are moderately prominent, sub-trigonal and oblique; vascular markings with their lateral divisions curving up backward and sending off several branches, while the other divisions extend forward and bifurcate so as to occupy the anterior region; anterior and lateral margins crenate within by very short striæ.

Surface of both valves ornamented by moderately stout, radiating striæ, the posterior lateral of which curve so strongly outward that a few of them run out on the cardinal edge before reaching the lateral margins; striæ of ventral valve nearly always increasing by bifurcation (some of them dividing two or three times); while those on the dorsal valve generally increase by the intercalation of shorter ones between the longer. A few distant, sub-imbricating marks of growth are sometimes seen toward the front and lateral margins; while on perfectly preserved specimens, the radiating striæ may sometimes be seen to be roughened by minute elevated concentric lines, that are more or less interrupted in crossing some of the striæ.

Length of a rather large, well-developed specimen, 0.96 inch; breadth, 1.30 inches; convexity, 0.43 inch.

This is a very well-marked species, readily distinguished from all of

its associates by its transversely subquadrate form, the strongly curved direction of its posterior lateral striæ, its nearly equal beaks, rather narrow area, and rounded posterior angles. It also presents well marked internal differences from the other species of its size in the group.

Locality and position: Upper part of the Cincinnati group, at Oxford and various localities in Ohio; Richmond and Madison, Indiana; Maysville, Kentucky, etc. Prof. Hall cites Cincinnati, Ohio, as one of its localities, but it does not occur there, the beds exposed there being below its horizon in the series in this State. I am indebted to Mr. James, Mr. Shaffer, and Mr. Miller, of Cincinnati, for fine specimens of this species.

Orthis occidentalis, Hall.

Plate 9, figs. 3 *a* to *h*.

Orthis occidentalis, Hall, 1847; Palæont. N. Y., Vol. I., p. 127, pl. XXXII. A, figs. 2 *a–m;* and pl. XXXII. B, figs. 1 *a–i*.
? Orthis sinuata, Hall; *Ib.*, p. 128, pl. XXXII. B, figs. 2 *a-s*.
? Orthis subjugata, Hall; *Ib.*, p. 129, pl. XXXII. C, figs. 1 *a–m*.

Shell attaining a moderately large size, wider than long, varying from transversely subquadrate to semi-oval, becoming quite gibbous with age; hinge line exceeding, about equaling, or sometimes a little less, than the breadth of the valves at any part farther forward; lateral extremities moderately compressed, varying from rather acutely to more or less obtusely angular; lateral margins often a little sinuous behind, but sometimes straight or convex in outline, but rounding to the front, which is nearly always a little sinuous, and sometimes rather decidedly so, in the middle.

Dorsal valve more convex than the other, especially in the large adult examples, its greatest convexity being generally a little behind the middle, on each side of a shallow, undefined mesial sinus, generally extending from the front to the umbonal region, but sometimes nearly or quite obsolete, or only represented by a slight flattening along the middle; swell of the umbo comparatively prominent, and often projecting backward farther than the beak of the other valve; beak rather strongly incurved; area of moderate height in the middle, but sloping to the lateral extremities, sharp along the margin, and more or less strongly incurved; foramen broad-triangular, and not closed by the cardinal process. Interior with scars of the adductor muscles situated on each side of a low mesial ridge, which is narrower between the anterior than the posterior pair, which latter are placed far back under the brachial processes, and rather strongly striated, but without well defined margins; anterior

pair somewhat trigonal, and usually each separated from the posterior by an obscure transverse ridge, but without well defined anterior margins; cardinal process merely presenting the appearance of a compressed or sharp ridge, much lower than the surface of the cardinal area; sockets distinct; brachial processes directed forward and more or less laterally, usually sharp on their inner under edges; vascular scars unknown.

Ventral valve most convex at or near the apex of the beak, from near which it slopes more rapidly to the front and lateral margins than to the anterior lateral, the anterior region being impressed so as to form a broad, more or less deep, undefined mesial sinus, that dies out before reaching the umbo; beak rather elevated, but not projecting backward, abruptly pointed, very nearly straight, or sometimes slightly arched at the point; cardinal area rather high at the beak, but sloping to the lateral extremities, flat or slightly arched, and usually standing nearly at right angles to the plane of the valve; foramen generally higher than its breadth at the hinge line, and extending to the apex of the beak. Interior showing the cardinal margin to be prominent and sharp, and the hinge teeth well developed; cavity for the reception of the muscular scars deep, nearly or quite reaching the middle of the valve, obcordate in form, and bounded by a prominent ridge continued forward from the bases of the hinge teeth, and curved a little backward at the central point of the front, where they meet; impressions of the divaricator muscles (cardinal, of some) deep; while those of the adjustors are so small, and pushed so far aside, as to occupy the sides of the dental plates, and thus to be out of sight in a direct view; those left by the adductors are narrow, elongated, and situated on each side of a mesial ridge that is divided along the middle by so wide and distinct a furrow as to appear almost like two linear ridges; transversely striated cavity within the beak very small, and broad-triangular; free margin crenate within, while the surface between this and the deeply impressed muscular cavity is usually smooth, or sometimes very minutely and obscurely corrugated; vascular markings unknown.

Surface of both valves ornamented by distinct, rather prominent radiating striæ, which, on the dorsal valve, nearly always increase by intercalation, and curved gradually outward, on the posterior lateral regions; while on the ventral valve they generally increase by bifurcation, and are nearly straight on all parts. A few distant, imbricating marks of growth are also usually seen around the free margins of adult examples; while well-preserved specimens show minute, but not crowded, prominent, concentric lines crossing the much larger radiating striæ, and the furrows between them.

Length of a mature, rather gibbous specimen, 1 inch; breadth, 1.24 inches; convexity, 0.80 inch. Some examples are proportionally decidedly broader, and others a little less so.

This species differs so clearly from the last, both in form and the details of its internal characters, that it seems to me unnecessary to enter upon a comparison of the two shells. On the other hand, however, it seems to be so connected by intermediate forms with *O. sinuata* of Hall, that I am inclined to believe them only varieties of the same species, although the typical forms of the two proposed species occur at somewhat different horizons; the *O. sinuata* being found at the horizon of about 350 feet above the river at Cincinnati, and the *O. occidentalis* at higher horizons in some of the counties farther northward and eastward in the same group of rocks. The Cincinnati shells (see 4 *a–f*) attain a somewhat larger size, and are not so produced on the hinge line as *some examples* of *O. occidentalis;* while they often have a more or less defined, mesial, rounded ridge (fig. 4 *a* and *d*) on the anterior slope of the dorsal valve, where we *usually* see a sinus in the *O. occidentalis.* This ridge, however, often fades away, and is sometimes (indeed frequently) entirely wanting in the Cincinnati specimens, and we find among them all gradations in this character, so that those with the ridge and those without it, merge gradually into each other. Again, at the localities where the typical forms of *O. occidentalis* occur, we find all gradations between those that have the mesial sinus of the dorsal valve well defined, to others in which no traces of it can be seen; so that it would be exceedingly difficult to separate the varieties of *O. occidentalis* from some forms of *O. sinuata.*

It is worthy of note, however, that although these variations do occur among the specimens from both horizons, I have seen no examples from the localities and position where typical specimens of *O. occidentalis* occur, with the mesial ridge on the dorsal valve seen on typical specimens of *O. sinuata;* nor any from the localities where *O. sinuata* occurs, with the mesial sinus sometimes seen on the same valve of *O. occidentalis.* The Cincinnati specimens of *O. sinuata*, before me, also *generally* have the beak and area of the ventral valve a little more inclined or curved backward than in authentic examples of *O. occidentalis*, but not *always.* Some of them, also, have rather finer striæ, but again they vary in this character also. There may possibly be two species among these shells from the two horizons; but with those I have yet had for study it seems scarcely possible to separate them. It is easy enough to pick out a number of typical examples of each, but when we undertake to separate a collection of specimens from the two horizons, we meet with many that cannot be

separated from either variety, and yet might apparently, with equal propriety, be referred to either or both.

In regard to *O. subjugata*, Hall, I would remark that there appears to be no reason to separate it from *O. sinuata*, whatever may be thought of the propriety of including the latter as a variety of *O. occidentalis*.

Several European authors have expressed the opinion that all of these proposed species are really only varieties of *O. porcata*, McCoy. In this opinion, however, I cannot concur. Mr. Davidson's beautiful figures of that shell show it not only to differ in being generally proportionally longer, with a shorter hinge, but those of the interior of the ventral valve show the cavity for the reception of the muscular scars to have an entirely different form, being much more deeply emarginated in front, with the two divisions more angular than in the American shell; while that species has its adjustor muscular scars quite distinctly visible in a direct view, instead of being crowded laterally out of sight, as in the shells under consideration. There are also differences in the striæ that have been pointed out by Mr. Davidson.

Locality and position: The specimens of *O. occidentalis* that I have studied were, in part, presented by Mr. James to the Smithsonian Institution, and in part collected by Mr. Case and myself. Those collected by Mr. James came from the upper part of the Cincinnati group, in Butler county, Ohio; and those collected by Mr. Case and myself were found at the same horizon at Richmond, Indiana. It also occurs at Oxford, Ohio, and Madison, Indiana, as well as at Savannah, Illinois, and in Iowa, Wisconsin, and at other localities in these States, at the same horizon. Prof. Hall mentions Cincinnati as one of the localities, but I have not seen the typical form from there; though the variety, or species *O. sinuata*, occurs near the tops of the hills at that city, as already stated.

Orthis insculpta, Hall.

Plate 9, figs. 1 *a* to *h*.

Orthis insculpta, Hall, 1847; Palæont. N. Y., Vol. I., p. 125, pl. XXXII., figs. 12 *a*, *b*, *c*.

Shell generally rather under medium size, wider than long, subquadrate, or transversely truncato-sub-oval; hinge line nearly always a little less than the greatest breadth of the valves, and meeting the lateral margins at an angle of usually more than ninety degrees; lateral margins generally moderately convex in outline, at or near the middle, and rounding regularly to the front, which is nearly always a little sinuous in the middle; valves moderately and nearly equally convex.

Dorsal valve with its greatest convexity usually a little behind the middle, on each side of a narrow, but moderately deep mesial sinus, that

extends from the beak to the front; posterior lateral regions distinctly compressed; beak but little prominent, and more or less incurved; area moderately developed, narrowing rather rapidly to the lateral extremities, directed backward, and more or less strongly arched; foramen broad-triangular, and partly occupied by the cardinal process, which usually projects slightly beyond the surface of the area, and is laterally compressed. Interior showing the brachial processes to be rather prominent and diverging; and the sockets for the reception of the teeth of the other valve distinct; scars of the adductor muscles (occlusors of some) situated on each side of a strong, prominent mesial ridge, behind the middle of the valve, those of the posterior pair being very narrow antero-posteriorly, and placed back directly under the brachial processes, nearly out of sight in a direct view; while the anterior pair are larger, oval in form, and extend forward nearly to the middle of the valve; vascular markings consisting of two principal lateral trunks that extend outward and forward from the anterior adductor scars, but immediately bifurcate, sending each a main division backward and outward, and another forward, each with subordinate branches; while between these principal trunks there are two pairs of smaller ones, and traces of a few other still smaller, all directed forward.

Ventral valve about as convex as the other, but having its most gibbous part farther back, near the umbo, from which point its surface slopes off regularly to the front and lateral margins, without any distinct mesial elevation or depression; beak moderately prominent, or projecting backward more or less beyond that of the other valve, and somewhat arched, but not properly incurved; area two or three times as high as that of the other valve near the beak, and sloping off rather rapidly to the lateral extremities, directed obliquely backward and downward, and a little arched with the beak; foramen usually higher than wide. Interior showing hinge teeth to be prominent and sub-trigonal; cavity for the reception of the muscular impressions scarcely extending forward to the middle of the valve, tapering a little toward the front, where it is more or less emarginate in the middle, moderately well defined by a rather obscure marginal ridge, and divided within, longitudinally, by a low, double ridge, that usually extends forward beyond the muscular cavity, where it suddenly contracts to a very narrow, obscure single ridge, that again expands, or bifurcates farther forward; scars of the divaricator and adjustor muscles not very distinctly separated, and those of the adductors not clearly seen in the specimens examined; ovarian areas comparatively rather large, and each occupied by a number of raised, linear, rather distant, and sometimes bifurcate ridges or lines that radiate forward and laterally.

Surface of both valves ornamented by distinct radiating striæ, that increase both by division and intercalation, and are crossed by much smaller, regular, distinctly defined, imbricating concentric marks, that are more prominent between, than upon the radiating striæ, and present a zig-zag appearance, by being deflected backward on the striæ, and forward in the depression between them; a few much stronger imbricating marks of growth are also usually seen near the free margins of adult specimens.

Length of a mature specimen not quite of the largest size, 0.60 inch; breadth, 0.78 inch; convexity, 0.35 inch.

This is a well marked species, that will be distinguished at a glance from any of the foregoing by its smaller size, more nearly equally convex valves, and particularly by its distinct, regular, imbricating markings, which give an ornate scolloped appearance to the furrows between the radiating striæ. It also presents well defined internal differences. The presence of a mesial sinus, extending to the beak, on its dorsal valve, and the absence of any corresponding fold on the other, are constant characters in this species.

I have no authentic specimens of *O. bellarugosa*, Conrad, at hand for comparison, but, judging from the figures and description of the same given in the New York Palæontology, as well as from Mr. Conrad's original description, his species would seem to be very closely related, in its external characters, to this; the chief difference being its smaller size.

Locality and position: Upper part of the Cincinnati group, at Oxford, Lebanon, and various localities in Butler, Warren, and Clinton counties. Prof. Hall also cites it from Cincinnati, Ohio; but the collectors there say it is not found at that locality, nor anywhere in that State, below the upper part of the Cincinnati group; though Prof. Hall also cites it from the Trenton in New York. I am under obligations for the use of an excellent series of specimens of this species, sent on to the Smithsonian Institution by Mr. James and Mr. Shaffer, of Cincinnati, and for a few from Mr. J. Kelley O'Neall, of Lebanon, Ohio.

Orthis borealis, Billings.

Plate 8, figs. 4 *a* to *f*.

Orthis borealis, Billings, 1859; Canadian Naturalist, Vol. IV., p. 436, figs. 14 *a*, *b*, *c*; and (1863) Geology of Canada, Report of Progress, p. 129, figs. 56 *a*, *b*, *c*; and *Ib.*, p. 167, figs. 168 *a*, *b*, *c*.

Orthis Frankfortensis, James, 1871; Cat. Lower Silurian Fossils, Cincinnati Group, p. 10.

Shell rather under medium size, transversely oval-subquadrate, or truncato sub-oval, the length and breadth varying, with relation to each other, from as 9 to 11, to 11 to 12; both valves convex; hinge line shorter

than the greatest breadth of the valves (which is usually a little in advance of the middle), meeting the lateral margins at more or less obtuse angles; lateral margins rounding to the front, which is rather broadly rounded, or possibly sometimes faintly sinuous at the middle.

Dorsal valve sometimes slightly more convex than the other, its most prominent part being near, or a little behind the middle, usually sloping rather more distinctly to the lateral margins than toward the front, where there is generally a broad, very low, undefined prominence, or mesial elevation; beak moderately prominent and arched, but not strongly incurved; area about half the height of that of the other valve, directed backward and more or less arched. Interior unknown.

Ventral valve most convex near the umbo, and sloping sometimes rather abruptly toward the posterior lateral angles, while the anterior central region is depressed so as to form a broad, very shallow mesial sinus, sometimes extending backward nearly or quite to the middle; beak more prominent than that of the other valve, rather abruptly pointed, inclined backward and moderately arched; area broad-triangular, well defined, and tapering to the lateral extremities of the hinge, inclined and a little arched backward with the beak; foramen rather narrow, or slightly higher than its breadth at the hinge. Interior unknown.

Surface of both valves ornamented by distinct, rather prominent, radiating ribs, about forty of which may be counted on each valve of a medium-sized specimen; the furrows between the ribs equaling the breadth of the ribs themselves; larger individuals sometimes having a few of the ribs bifurcating once, and an occasional smaller one intercalated between two of the larger, so as to increase the whole number at the free margins to about fifty. Concentric striæ nearly or quite obsolete; but, in old specimens, one or more sub-imbricating marks of growth may sometimes be seen near the free margins.

Breadth of largest specimen seen, 0.74 inch; length, 0.64 inch; convexity, 0.33 inch. Breadth of a smaller specimen, 0.56 inch; length, 0.47 inch; convexity, 0.26 inch.

It is possible that a comparison of a good series of specimens of this shell and the Canadian species, showing internal as well as external characters, might bring to light some differences that would warrant their separation but with the means of comparison now accessible, I am led to think that they belong to the same species. Compared with Mr. Billings's figures of *O. borealis*, the western specimens before me differ only in having the anterior margin rounded, instead of straight or slightly sinuous in the

middle; while one of them has a few of the ribs bifurcating, and a few smaller ones, at intervals near the margins, intercalated between the others. One of them also has its hinge line proportionally shorter than represented in his figures. Mr. B., however, distinctly states that his species is somewhat variable in these characters, some having, like ours, an indistinct mesial fold on the dorsal valve, and these are rounded, instead of straightened, or slightly sinuous in front; while others have a slight flattening or depression on the middle of this valve, which, together with the mesial sinus of the other, cause the obscurely sinuous character sometimes seen at the middle of the front.

As he states, it closely resembles *O. plicatella*, but is more convex, and has more numerous and smaller costæ. It is also less transverse, and has generally a shorter hinge line, while the mesial sinus of its ventral valve, and the fold of the other, are more decidedly marked.

Through the politeness of Mr. Billings, I have, since writing the foregoing, had an opportunity to compare our specimens with Canadian examples of his species, and have been unable to find any satisfactory external specific differences.

Locality and position: Frankfort, Kentucky, in the horizon of the Trenton limestone, and in the lower part of the Cincinnati group, at Cincinnati, Ohio. Mr. U. P. James's collection. The larger specimen figured is from the former locality and position, and the other from the latter. In Canada, *O. borealis* is cited from the Chazy and Trenton limestones.

Orthis bellula, James.

Plate 8, figs. 5 *a* to *f*.

Orthis bellula, James, 1871; Cat. Lower Sil. Fossils, Cincinnati Group, p. 10 (without figure or description).

Shell very small, longitudinally semi-oval, or transversely sub-oval, moderately gibbous, sub-equivalve; breadth always greater than the length; hinge line a little less than the greatest breadth of the valves; posterior lateral extremities abruptly rounded, or sub-angular; lateral margins rounding to the front, which is broadly semi-elliptic in outline, or sometimes a little straightened, or even very faintly sinuous at the middle. Interior unknown.

Dorsal valve less convex than the other, with usually a very slight, scarcely perceptible mesial depression near the umbo, that rarely, if ever, extends forward to the middle; beak small, projecting slightly

beyond the edge of the area, and merely a little arched; area of comparatively moderate height, flat, or somewhat arched, and inclined more or less obliquely backward and upward; foramen forming a nearly equilateral triangle.

Ventral valve most convex near the umbo, and perhaps always showing a very shallow, broad, undefined mesial sinuosity at the front; beak moderately prominent, pointed, inclined backward and a little arched, but not incurved; area comparatively rather high, or from twice to three times the height of that of the other valve, well defined, a little arched, and inclined obliquely backward and downward; foramen narrow-triangular, and extending to the point of the beak.

Surface of both valves ornamented by very fine radiating striæ, most of which bifurcate two or three times between the beaks and free margins; the lateral ones being moderately arched.

Length of a medium-sized specimen, 0.23 inch; breadth, 0.28 inch; convexity, 0.13 inch.

This little shell, notwithstanding its small size, has the appearance of having attained its mature growth; while it seems to differ too much in various respects to be the young of any of the other known forms found in the same association. It seems to be most nearly allied to *O. perveta* of Conrad, from the horizon of the Trenton group, in Wisconsin; and possibly it may be a dwarfed variety of the same. I am led to think this can scarcely be the case, however, not only because it is much smaller, but from the fact that its cardinal extremities are more rounded, and the area of its dorsal valve decidedly lower in proportion to that of the other valve, than is represented by the figure of Conrad's species given in the first volume of the New York Palæontology.

That species is also described by Prof. Hall as having the ventral valve (dorsal, as it was then called), "with a broad elevation in front;" while in the shell under consideration there is, on the contrary, a broad, very faint concavity, or undefined mesial sinus there. Again, both Mr. Conrad and Prof. Hall describe the striæ of *O. perveta* as "bifurcating on the umbo," and say nothing indicating that they bifurcate again farther forward; while they generally bifurcate twice or three times on the little shell under consideration.

Locality and position: About 300 feet above low-water mark, at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian. The description is made out from the type specimens belonging to Mr. James, and others sent to the Smithsonian Institution by Mr. Miller, of Cincinnati, Ohio.

Orthis (?) ella, Hall.

Plate 8, figs. 9 *a, b, c, d.*

Orthis ella, Hall, 1861; Regents' 13th Ann. State Cab. Report, p. 121; also 15th do. (1862), pl. 2, figs. 6–8; and in illustrations of a paper on some fossils from Cincinnati, dated Oct., 1871, issued in advance of Regents' 24th Report, pl. 3, fig. 21.

Trematospira? ella, Hall, 1862; Explanations of pl. 2, Regents' 15th Report.

Shell small, varying from sub-orbicular to transversely (or rarely longitudinally) sub-oval; rather convex, the valves being nearly equally so; hinge line extremely short, or only about one-third the breadth of the valves, and not imparting any angularity to the posterior lateral margins, which slope at various angles from the beak; lateral margins generally more narrowly rounded than the front, but sometimes the reverse. Internal characters unknown.

Dorsal valve rather evenly convex, but generally very faintly raised at the middle of the front, while its greatest convexity is usually a little behind the middle; beak closely incurved, so as to hide the very small area (if any exists).

Ventral valve most convex at or behind the middle, and slightly impressed, so as to show indications of a very shallow sinus at the front margin; beak projecting moderately beyond that of the other valve, rather pointed, directed backward and arched, but not incurved; area exceedingly small, scarcely more than twice as wide as high, rather well but not sharply defined, and arched and directed backward with the beak; foramen comparatively large, about as wide at the hinge line as its height, triangular, but narrowed above and extending quite to the apex of the beak, where it terminates in a minute opening.

Surface ornamented by from about twenty-three to fifty or more simple radiating plications on each valve, equaling the size of the furrows between. Marks of growth obsolete.

Length of a rather broad specimen, 0.32 inch; breadth, 0.36 inch; convexity, 0.20 inch.

As remarked by Prof. Hall, this little shell is almost certainly not an *Orthis*, its hinge line being shorter, and its area much smaller, than is common in that genus; while it presents the appearance of having a tendency to form a minute, round perforation at the apex of the beak of the dorsal valve. It might be referred to *Retzia*, or *Trematospira*, if it were not for its rather distinct, though small, cardinal area, and open triangular fissure. Its internal characters would possibly show it to belong to an undescribed genus, if they could be determined.

It seems to be a rather rare species, and might be confounded, by a careless observer, with some of the other small brachiopods of the Cincinnati beds; though its extremely contracted cardinal area, and other characters, will enable any one accustomed to examine such fossils to identify it readily, on a careful examination. It is a very variable little shell, both in form and in the number and size of its costæ.

Locality and position: Cincinnati group of the Lower Silurian, at an elevation of about 300 feet above low-water mark of the Ohio. Mr. U. P. James's collection.

(*Non-resupinate species.*)

Orthis fissicosta,* Hall.

Plate 8, figs. 6 *a* to *h*.

Orthis fissicosta, Hall, 1847; Palæont. N. Y., Vol. I., p. 121, pl. XXXII., figs. 7 *a*, *b*.
Comp. *O. dichotoma*, Hall; *Ib.*, p. 125, pl. XXXII., figs. 13 *a*, *b*.

Shell small, or under medium size, only moderately convex, semi-oval, or approaching semicircular in outline, the length being two-thirds to four-fifths the breadth; hinge line very nearly or quite equaling the greatest breadth of the valves; posterior lateral extremities rectangular; lateral margins rounding to the front, which is broadly rounded, or sometimes slightly straightened along the middle.

Dorsal valve somewhat less convex than the other, its most prominent part being at or a little behind the middle; beak projecting but slightly beyond the margin of the area, and a little arched; area about one-fourth as high as that of the other valve near the triangular foramen, but narrowing to nothing at the lateral extremities of the hinge, directed backward nearly on the plane of the valves, and nearly or quite flat. Interior showing the plications of the outer surface strongly defined, owing to the thinness of the shell, but without any defined muscular scars, so far as known; cardinal process small, laterally compressed, and not filling the foramen; sockets obscure; brachial processes little developed, or so thin as to be usually broken; each supported by a very thin, short lamina, immediately under the area.

Ventral valve with its greatest convexity near the umbo, thence sloping forward and laterally—sometimes with a broad, very shallow, scarcely perceptible upward wave of the middle part of the front; beak abruptly pointed, inclined backward beyond the hinge, but not much incurved; area moderately high at the beak, and sloping, with nearly or quite

* This species and *O. plicatella*, as well as two or three of the immediately preceding species, stand rather intermediate between the resupinate and non-resupinate forms.

straight, sharp margins to the lateral extremities of the hinge, moderately arched, and rather strongly inclined backward; foramen narrow, and extending to the apex of the beak. Interior having plications strongly impressed through, as in the other valve; muscular cavity small, shallow, not reaching the middle of the valve, rounded in front and narrowing to the beak, so as to present an oval-sub-trigonal outline, margined on each side by very low linear dental ridges, that do not continue around the front; hinge teeth apparently nearly obsolete.

Surface of both valves ornamented with strong, elevated, rather straight, radiating striæ, which usually, in part, become bifid or trifid; while on other parts they increase in number by the intercalation of a smaller one between two of the larger. On well-preserved specimens, very minute crowded concentric striæ are also usually visible by the aid of a magnifier, mainly in the furrows between the striæ.

Length of a rather large specimen, 0.57 inch; breadth, 0.73 inch; convexity, 0.26 inch.

I am not sure that I have had authentic examples of *O. dichotoma*, Hall, for comparison; but judging from the figures and description of that shell, as well as from specimens that have been identified with it by others, there would seem to be very little to distinguish it from the species under consideration. *O. plicatella*, Hall, is also another similar form, that, although strongly distinct when we compare its typical variety, shades into this by so many intermediate gradations, that it is not always easy to distinguish certain varieties of the two types.

Prof. Hall's typical figured specimen of the form under consideration has the beak and area of the ventral valve more arched than in any examples of *O. plicatella*, or *O. dichotoma*, I have seen; but among the numerous examples before me from Cincinnati, agreeing in all other respects with his type of *O. fissicosta*, scarcely any of them have the beak so much arched as represented in his figure, though some of them approach it in this respect also. His specimen, however, is evidently, as he states, distorted by pressure, and this may have, in part, caused this difference.

Prof. Hall compares it with *O. calligramma*, Dalman, and *O. actoniæ*, Sowerby, but it seems to me too obviously distinct from both of these forms (of which I have good European examples at hand for comparison) to require any remarks on their distinguishing characters.

Locality and position: Cincinnati group of the Lower Silurian, at the horizon of about 300 feet above low-water mark of the Ohio, at Cincinnati. I am under obligations for the use of good specimens of this species sent to the Smithsonian Institution by Mr. James, Mr. Miller, and Mr. Shaffer, of Cincinnati.

Orthis plicatella, Hall.

Plate 8, figs. 7 *a* to *h*.

Orthis plicatella, Hall, 1847; Palæont. N. Y., Vol. I., p. 122, pl. XXXII., figs. 9 *a*, *b*, *c*, *d*, *e*, *f*, *g*.

This form, as already indicated, is so closely connected with the last, through a series of intermediate varieties, that a formal description is unnecessary. Looking at the typical varieties of each, although they agree in form and general appearance quite nearly, they may be distinguished at a glance by the nearly or quite simple, larger, and less numerous plications of the form under consideration. In separating a large collection of the two forms, however, we soon meet with specimens with the larger and less numerous plications of *O. plicatella*, that have a few of these plications, at the immediate margin, beginning to show faint, but unmistakable, indications of a tendency to divide, and the interspaces to develop an occasional intermediate smaller plication. In other individuals we find these divisions of the plications and the intercalated ones becoming more frequent, and extending farther inward from the margins, until we pass through an almost uninterrupted series, to forms presenting nearly all of the characters of *O. fissicosta*.

A single specimen of the form under consideration, now before me, shows the hinge and interior of its dorsal valve. In this the muscles have left no visible scars whatever, and the brachial processes are small, the sockets obscure, and the cardinal process compressed laterally so as not to fill the foramen, above the margins of which it does not project. It also shows no vascular markings. Consequently, it will be seen that at least in the dorsal valve there are no known internal differences between this shell and *O. fissicosta*. I have not, however, had an opportunity to compare the internal characters of its ventral valve with those of *O. fissicosta*, and do not feel prepared to say that they are merely varieties of the same species.

From the same locality and position, Mr. S. A. Miller, of Cincinnati, sent to me two specimens (see pl. 8, figs. 8 *a* to *e*) having the same form, coarse costæ, and general appearance of *O. plicatella*, but differing in attaining a larger size, and in having the area of the ventral valve *decidedly* lower, and the beak of the same more incurved than in any well-characterized specimens of that form I have seen. It also differs in having the costæ much more widely separated by deeper furrows, and each giving off a smaller lateral division from near the middle of the valves; the main ones, however, continuing larger and more prominent to the free margins thus forming bundles of three ribs, with a wide, deep depression between.

The largest specimen of this form I have seen, measures as follows: Breadth, 1.04 inch; length, 0.70 inch; convexity, 0.40 inch.

I strongly suspect that this should be separated specifically from *O. plicatella*, but these forms vary to such an extent that I feel some reluctance in proposing to separate it as a distinct species, without knowing anything about its internal characters.

In the American Journal of Science and Arts, Vol. IV., 3d series, p. 281, I proposed for this type, in case it should be found to be constant in the characters mentioned, the name *O. triplicatella*, which may be retained if desirable.

Locality and position: Same as last. The specimens studied were sent to the Smithsonian Institution by the same gentlemen that sent those of the last.

Orthis emacerata, Hall.

Plate 8, figs. 1 *a* to *d*, and figs. 2 *a* to *g*.

Orthis emacerata, Hall, 1860; Regents' 13th State Cab. Report, p. 121; and 15th do. (1862), pl. 2, figs. 1 and 2.

Compare *O. testudinaria*, Dalman, 1827; Kongl. Vetensk. Acad., Handl., p. 115, pl. II., figs. 4 *a*, *b*, *c*, *d*, *e*.

Shell small, plano-convex, rather depressed, transversely truncato-sub-oval, the length being about five-sixths its breadth; hinge line perhaps always a little shorter than the greatest breadth of the valves; lateral margins generally rounding to the hinge, most prominent at or a little behind the middle, and rounding to the front, which is usually somewhat straightened, or very faintly sinuous, at the middle; or presents a regular semicircular outline.

Dorsal valve nearly flat, or slightly convex on each side of a shallow mesial sinus, that commences very narrow at the beak, and usually widens rather rapidly to the front; beak very small, scarcely projecting beyond the edge of the area, and not incurved; area low at the middle, and narrowing off to nothing at the lateral extremities of the hinge, slightly arched, and directed obliquely backward; foramen very small, and filled by the cardinal process. Interior very shallow, and provided with a slender mesial ridge that extends about half way forward from the hinge, between the muscular impressions, which are not usually well defined; scars of posterior pair of adductor muscles smaller, and usually deeper, than the anterior, and situated close back under the brachial processes; those of the anterior pair three or four times the size of the posterior, sub-oval in form, and extending to near the middle of the valve; cardinal process very small and trifid; brachial processes comparatively rather stout and prominent; internal surface having the radiat-

ing striæ of the exterior rather distinctly impressed through, as it were, in consequence of the thinness of the shell, and finely granular, the granules being apparently connected with the punctate structure of the shell.

Ventral valve compressed-convex, the greatest convexity being near, or a little behind the middle, along a more or less prominent, undefined ridge, that sometimes, but not always, imparts a sub-carinate appearance to the central and umbonal regions; beak small, projecting somewhat beyond that of the other valve, abruptly pointed, and rather distinctly arched, but not strongly incurved; area about twice as high as that of the other valve, and with its sharply defined edges sloping to the lateral extremities of the hinge, directed and arched obliquely backward with the beak; foramen having nearly the form of an equilateral triangle, but rather narrowed upward to the apex of the beak, and partly occupied by the cardinal process of the other valve. Interior showing the teeth to be moderately prominent; concavity for the muscular impressions very shallow, small, somewhat bifid anteriorly, and not defined by a very distinct marginal ridge; scars of divaricator muscles apparently narrow, and situated on each side of a shallow mesial depression, which seems to include, far back at its posterior end, those of the very small adductors, merely separated from each other by a hair line; impressions of ventral adjustor muscles apparently wider and shorter than those of the divaricators; striæ and fine granules of the interior as in the other valve.

Surface of both valves ornamented by numerous, distinct radiating striæ, that usually bifurcate about three times between the beak and free margins; posterior lateral striæ so strongly curved that a part of them run out on the hinge line. Numerous very minute, regularly disposed, concentric lines, may also be seen by the aid of a magnifier, most istinctly defined in the furrows between the much larger radiating striæ; while a few distant, sub-imbricating, stronger marks of growth are usually seen in adult shells.

Length of a medium-sized mature specimen, 0.60 inch; breadth, 0.75 inch; convexity, 0.25 inch.

I am in considerable doubt whether it was this or the following form to which Prof. Hall applied the name *O. emacerata*. His remark that his type has finer striæ, and the depression in the middle of its dorsal valve usually deeper, and the mesial elevation of the ventral valve more prominent, than in the form most generally referred to *O. testudinaria*, would seem to indicate that he had the following form in view, and regarded that here under consideration as the *O. testudinaria*. His figure, however, cited above, particularly figure 1, is larger than any example of the following

form I have seen, and agrees decidedly more nearly in outline and general appearance with that here under consideration. I do not believe, however, that there is any specific, or other *constant* difference, between this shell and the western specimens that have long been referred to *O. testudinaria*, Dalman.

I have had no opportunity to compare these shells with authentic examples of Dalman's species, or even with English specimens referred to the same. A careful comparison, however, with Mr. Davidson's figures of English specimens referred to *O. testudinaria*, leads me to doubt whether they can be properly included in the same species with the latter. For instance, the English specimens would seem, according to Mr. Davidson's figures, not only to be proportionally longer, with a more convex dorsal valve, and a more prominent and incurved ventral beak, but also to differ in having their posterior lateral striæ only gently curved, instead of being so strongly arched as to run distinctly out on the hinge line, as we see in all of the specimens of the western form under consideration. Again, there are rather marked and constant differences in the form and proportions of the muscular scars in the shell under consideration, from the same, as represented in Mr. Davidson's figures referred to. For instance, these figures show the posterior pair of adductor scars in the English shell a little larger than those of the anterior pair; while in the form under consideration, the reverse is constantly and decidedly the case. Again, his figure of the interior of the ventral valve shows the cavity for the reception of muscular scars to be narrower, in proportion to length, with the divisions of its anterior end differently formed; while the scars of the adductor muscles in the American shell are placed decidedly farther back than represented in Mr. Davidson's figure. How far the English specimens may vary in these characters of the muscular impressions, I have no means of knowing, though I have found the American shells quite constant in their internal characters. Mr. Salter's figures, however, given on plate XXVII., Vol. II., part 1, of the Memoirs of the Geological Survey, show that at least some of the English shells referred to *O. testudinaria* have the posterior lateral striæ as strongly curved as in any of our American shells of this type, and also agree quite well with the latter, in at least all external characters.

Locality and position: Cincinnati group, Cincinnati, Ohio, at an elevation of 250 feet above the Ohio; this being the typical form, like Prof. Hall's fig. 1, in the Regents' Report. I also, however, have specimens differing very little, if any, from higher horizons, both at Cincinnati and Butler county, Ohio. A few others, from Cincinnati, agree with the more transverse form represented by Prof. Hall's figure 2; and Prof. Orton has sent to me from Hamilton, Ohio, near the top of the group, a number of specimens agreeing exactly with that figure in outline and fineness of striæ.

Orthis emacerata, var. multisecta, James.

Plate 8, figs. 3 *a, b, c, d.*

Orthis multisecta, James, 1871; Cat. Lower Silurian Fossils, Cincinnati Group, p. 10.

This form, although somewhat variable, differs from the last in being smaller, slightly less transverse, and in having its dorsal valve generally flatter, with usually, but not always, a less defined mesial sinus; and its ventral valve with a less prominent mesial ridge. Its surface striæ are also a shade finer, and the minute concentric lines in the furrows between the striæ more distinct. The granules of its entire internal surface are likewise a little finer and more crowded.

The cavity for the reception of the muscular scars of its ventral valve is also proportionally a little smaller, and sometimes differs from that of the last, in wanting the bilobed character anteriorly, seen in the same part of that shell. There are, again, some slight differences in the form and proportions of the muscular scars of its other valve, but I am not quite sure that these are constant.

The external differences mentioned above give these shells a perceptibly different aspect, when we place, side by side, a tray-full of each; the form under consideration having altogether a more delicate and less robust appearance. It may be specifically distinct from the last, but I am not clearly satisfied that it is more than a variety of the same. It differs from Mr. Davidson's figures of *O. testudinaria* quite as strongly as the last; but it is possible that both may be only varieties of that species.

One of the largest specimens gives the following measurements: Length, 0.50 inch; breadth, 0.58 inch; convexity, 0.20 inch.

Locality and position: Lower division of the Cincinnati group, at Cincinnati, Ohio, where it ranges upward about 200 feet above low-water mark of the Ohio. The specimens studied were sent by Mr. James, Mr. Miller, and Mr. Shaffer, of Cincinnati, to the Smithsonian Institution.

Orthis (Platystrophia) biforata, Schlotheim (sp.).

Plate 10.

Terebratulites biforatus, Schlotheim, 1820; Petrefact., p. 265.

Terebratula lynx, Eichwald, 1830; Nat. Kizze von Podol., p. 202.

Porambonites dentatus and *brevis*, Pander, 1830; Bietr. Geogn, Russl., p. 96, pl. II., figs. 4, 5.

Spirifer lynx, Von Buch, 1837; Ueber Delth., p. 44; and (1840) Mem. Geol. Soc. Fr., Vol. IV., p, 190; Vern. and Keys. (1845), Geol. Russ., Vol. II., p. 136, pl. III., figs. 3 *a, b*, and 4 *a, b* (as varieties of *S. biforatus);* Hall (1852), Palæont. N. Y., Vol. II., p. 65, pl. 22, figs. 1 *a–e* (as var. *S. biforatus*).

Spirifer biforatus, Eichwald, 1840; Sil. Syst. in Esthel., p. 144; Vern. and Keys., 1845, Geol. Russ., Vol. II., p. 139.

Delthyris brachinota, Hall, 1843; Geol. Report 4th Dist. N. Y., p. 71, fig. 6.

Spirifer Sheppardi, Castlenau, 1843; Terr. Sil. de l'Amer. du Nord, p. 43, pl. XIV., fig. 15.

Spirifer dentatus, Vern. and Keys., 1845; Geol. Russ., Vol. II., p. 138, pl. III., figs. 5 *a*, *b*, *c*, *e*, *f* (as var. of *S. biforata*).

Delthyris biforata, Hall, 1847; Palæont. N. Y., Vol. I., p. 132.

Delthyris lynx, Hall, 1847; *Ib.*, p. 133, pl. XXII. D, figs. 1 *a-k* (as varieties of *D. biforata*).

Orthis biforata, Davidson, 1848; Bull. Geol. Soc. Fr. (2d series), Vol. V., p. 323, pl. III., fig. 25; and (1853) Introduct. to Brach., pl. VIII., figs. 146 and 148; Salter (1859), Siluria (2d series), p. 210, pl. XXXIII., fig. 4; Lindstrom (1860), Gothl. Brach., p. 371; Davidson (1871), Monogr. Brit. Sil. Brach., p. 268, pl. XXXVIII., figs. 11–25; James, 1871, Cat. Cincinnati Fossils, p. 10.

Spirifera biforata, Phillips and Salter, 1848; Mem. Geol. Survey, Vol. II., p. 293; McCoy (1852), Brit. Pal. Fossils, p. 192; Hall (1852), Palæont. N. Y., Vol. II., p. 65.

Platystrophia biforata, King, 1849; Mongr. Permian Fossils, p. 106.

Orthis lynx, Quenstedt, 1851; Handb., p. 486, pl. XXX., figs. 8–11; Schmidt, 1858, Sil. Fom. Ehst., etc., Arch., Vol. II., p. 215.

Spirifera lynx, *S. dentata* and *S. fissicostata*, McCoy, 1852; Brit. Pal. Foss., p. 192 and 193 (as varieties of *S. biforata*).

The original typical form of this species has, I believe, never been figured, and Schlotheim's description of it is so brief and unsatisfactory, that it would apply equally well to almost any of the various similar forms usually included as varieties or sub-species under his name. M. de Verneuil, however, states that he was informed by M. von Buch, that he had seen the original type in one of the museums at Berlin, and that it only differs from the common var. *lynx*, in having five plications in the mesial sinus, and a greater proportional breadth. Prof. McCoy describes it, from British specimens, supposed by him to be identical, as "having the mesial fold wider, and less elevated, bearing usually from six to nine ribs, at six lines or less from the beak, and five to seven in the sinus; the lateral ribs narrow, simple, and from nine to twelve on each side, at six lines from the beak."

Among the vast number of American specimens of this group that I have seen, none agree with the characters attributed to the variety *biforata* by Prof. McCoy; though we do very rarely meet with an individual that differs in no other respect from the common variety *lynx*, showing four, or even occasionally five, plications in the sinus; but still, in these cases, the additional plications are merely rudimentary, and placed on one or both sides of the usual three well-developed ones, occupying the bottom of the sinus. I can therefore but regard these as only

very slight modifications of the common variety *lynx*, and hence feel at a loss to know whether or not we have any form in this country agreeing *exactly* in all respects with the typical variety *biforata;* especially as we have no means of knowing whether the greater proportional breadth mentioned as characterizing that form, is due to the greater proportional extension of the hinge line and lateral angles only, or to the greater breadth of the entire shell.

I have therefore preferred to give the general synonymy so as to include only the forms that have been usually regarded as belonging to this species, by the highest European authorities; and then proceed separately to notice provisionally, as varieties, the several types known in this country, that are more or less closely connected with Schlotheim's species. Some of these may be entitled to rank as distinct species from the European forms, and I have therefore placed their synonymy separately in connection with the remarks upon each form. In defining each, it is only necessary to describe at length the most common and widely distributed form usually considered the variety *lynx*, and then to point out the character distinguishing each of the others from the same.

The differences of form, nearly equal beaks, areas and fissures in the two valves of these shells, give them a peculiar physiognomy, that seems to warrant their separation from the typical forms of *Orthis*, at least subgenerically.

Var. 1. Orthis (Platystrophia) lynx, Von Buch.

Plate 10, figs. 1 *a, b, c, d, e.*

Shell attaining a large size, nearly equivalve, wider than long, with a transversely oval-subquadrate outline, or, in old specimens, often becoming so gibbous as to assume a sub-globose form; hinge line usually a little less than the greatest breadth of the valves, but sometimes equaling, or somewhat exceeding, the same; cardinal extremities more or less obtusely angular, nearly rectangular, or sometimes rather acutely so; lateral margins convex, nearly straight, or sometimes rather sinuous behind, and rounding to the front, which is a little sinuous, rounded, or somewhat prominent at the middle; beaks and cardinal areas of the two valves nearly equal, the former incurved and approximate, or, in adult shells, sometimes contiguous.

Dorsal valve generally a little more convex than the other, in some examples rather decidedly so (its greatest convexity being near the mid-

dle), provided with a moderately prominent, rather rounded, mesial fold, that commences at or near the beak, and continues forward, gradually widening and rounding over with the curve of the valve to the front, where it is moderately elevated, with more or less sloping sides; lateral slopes convex; beak projecting beyond the hinge margin, strongly incurved, particularly in old individuals, which sometimes have the gibbous umbo projecting even a little beyond that of the other valve; cardinal area well developed, distinctly defined, nearly as wide as that of the other valve, directed backward, and more or less strongly incurved; foramen broad-triangular, and not closed by the cardinal process. Interior showing cardinal process to be very small, or merely having the character of a low linear ridge in the rostral cavity; posterior pair of muscular impressions corrugated, and decidedly larger, and more widely separated than the others.

Ventral valve with a mesial sinus corresponding to the fold in the other valve, and terminating at the front in a rather short, somewhat rounded projection, that curves more or less upward into a sinuosity of the same size and form in the margin of the dorsal valve; beak usually a little less strongly incurved than that of the other, and very slightly more prominent at its apex; cardinal area about one-fourth to one-third higher, at the middle, than that of the dorsal valve, and narrowing less rapidly toward the lateral extremities; incurved and directed backward, but a little less strongly so than the other; foramen having nearly the form of an equilateral triangle, or sometimes slightly wider than high, or the reverse. Interior with hinge teeth moderately prominent, and trigonal; cavity for the reception of the muscular attachments comparatively small, scarcely reaching the middle of the valve, longer than wide, or elongate-oval, with nearly straight and parallel sides, always well defined by the dental ridges, and, in old specimens, extremely profound, owing to the thickening of the interior of the cardinal region of the valve on each side.

Surface of each valve ornamented by about sixteen to twenty-four strong, more or less angular radiating plications, of which three or four (rarely five) occupy the mesial sinus, and from four to six the mesial fold; plications generally simple, but occasionally some of those in the sinus and on the fold, and, still more rarely, a few of those on the lateral slopes, bifurcating once; lines of growth moderately distinct, particularly near the free margins of adult shells, where they present a distinctly zig-zag appearance in crossing the plications and the furrows between them. Protected portions of the surface of well-preserved specimens also often show, under a strong magnifier, numerous regularly

arranged, minute granules, probably coincident with the punctures of the shell substance.*

Length of a nearly medium-sized adult specimen, 1 inch; breadth, 1.30 inches; convexity, 1 inch. Some examples attain a greater size, by two-thirds, than this, and are proportionally rather more gibbous.

Locality and position: This form has a great vertical as well as horizontal range. In New York, as well as Canada, Wisconsin, Kentucky, etc., it occurs in the Trenton group. In Ohio it is common at the horizon of the tops of the hills in the Cincinnati group, at Cincinnati; and it ranges up through the higher beds of this formation in Ohio, Indiana, Kentucky, and other western States, but it has not, I believe, been found in the equivalent formation in New York; though it occurs there, as well as in Ohio and other western States, as high in the series as the Clinton group. It is likewise found in Russia, England, and other European countries.

Var. 2. Orthis (Platystrophia) laticosta, James.

Plate 10, figs. 4 *a, b, c, d, e, f.*

Orthis lynx, Hall (part), 1847; Palæont. N. Y., Vol. I., pl. 32 D.
Orthis laticosta, James, 1871; Cat. Lower Sil. Foss., Cincinnati Group, p. 10.

This form scarcely attains to more than two-thirds the bulk of the largest specimens of the var. *lynx*, and is always less gibbous, proportionally wider on the hinge line, with more angular posterior lateral extremities, and, even in the largest individuals, it is a much thinner shell. It likewise differs in having its mesial sinus wider and much more profound at the front, and its mesial fold more elevated and angular; while its lateral slopes are decidedly more compressed, those on each side of the sinus being always concave, and the margins of the sinus very prominent and angular, which, together with the prominence of the mesial fold, and the greater length of the hinge line, impart a general angularity of appearance not seen in the var. *lynx*. In the sinus there are nearly always three plications, the lateral two being smaller than the middle one, or sometimes rudimentary; while occasionally one of them is obsolete, leaving the large one, as usual, in the middle, and a smaller one on one side only. The mesial fold has generally four plications (never more), the middle two being usually larger and more prominent than the others, and separated by a decidedly larger and deeper furrow. Its lateral slopes have generally only from five to seven large, simple, angular plications on each side of the fold and sinus; these being decidedly larger than on specimens of the var. *lynx*, of corresponding size.

Internally, the ventral valve of this variety only differs from that of the var. *lynx*, in having the cavity for the muscular scars much less deeply

* These granulations are quite as well, or even better defined, on all of the following forms described as varieties of this.

impressed, owing to the fact that the shell did not thicken within, as in that form, as it advanced in age. The interior of its dorsal valve shows the same rudimentary cardinal process; while its muscular scars (which I have not seen in this valve of the var. *lynx*) are moderately defined, the posterior pair being corrugated, and much larger, as well as more widely separated, than the anterior.

In figuring this variety in the first volume Palæont. New York, Prof. Hall compares it with the var. *dentata* of Pander, mentioning some points of difference. It attains a much larger size, however, than that variety, and differs in having nearly always three plications, instead of only two, in the sinus, which is deeper, and its mesial fold more prominent, thus giving the general aspect of the shell greater angularity of outline.

The specimens for which Mr. James retains the name *O. profundo-sulcata*, in his list, are much smaller than the average size of the form here under consideration; but, with that exception, and their usually rather shorter hinge, and somewhat less compressed lateral slopes, they seem to me to differ very little, if any, from specimens of the same size of the variety under consideration. On the other hand, they only differ from the young of the variety *lynx*, in generally having the mesial sinus deeper, and the fold more prominent, with, perhaps, in most cases one or two plications less on the lateral slopes. I have, therefore, found it very difficult to distinguish this as a variety from young or dwarfed examples of the varieties *lynx* and *laticosta*, though its more prominent fold, etc., bring it nearer the latter. Figs. 2 *a*, *b*, *c*, *d*, of plate 10, show the form and usual size of this variety. It occurs 300 feet above the Ohio, at Cincinnati.

Length of the largest example seen, 0.86 inch; breadth (at hinge line), 1.40 inches; convexity, 0.88 inch.

Locality and position: Cincinnati group of the Lower Silurian, at a horizon of from 250 to 300 feet above low-water mark, at Cincinnati. It is also found at other localities in Ohio, Kentucky, and perhaps in Indiana. The specimens studied were sent to the Smithsonian Institution by Mr. James and Mr. Shaffer, of Cincinnati.

Var. 3. Orthis (Platystrophia) dentata, Pander??

Plate 10, figs. 3 *a*, *b*, *c*, *d*.

Orthis dentata, (Pander), James, 1871; Catalogue Cin. Foss., p. 10.

This form is much smaller than the last, and always proportionally narrower in its transverse diameter. Its hinge line generally about equals the greatest breadth of the valves, but may be a little less or a little greater than the breadth. Its lateral slopes are always more abrupt,

and much less compressed than in the last; but, like that variety, its mesial sinus is large, and very profound, with angular margins, and its mesial fold strongly elevated. In old individuals, the valves become often remarkably gibbous, the convexity exceeding the length, and nearly equaling the breadth; being much increased by the prominence of the mesial fold, and the elevation of the plications forming the margins of the sinus. It also differs from the last in generally having but a single strong plication in the sinus, and only two on the mesial fold; though we sometimes see an individual with the commencement of a second smaller plication, occupying one of the slopes of the sinus on one side of the middle one, and very rarely one with a third one on the other side. Where rudimentary plications exist in the sinus, they usually give origin to corresponding partly developed plications on the slopes of the mesial fold of the other valve. All of the plications are simple, and, excepting the rudimentary ones mentioned, quite coarse, prominent and angular; the number on each lateral slope being constantly five or six.

This is the form referred in Mr. James's list to *O. dentata* of Pander. I doubt very much, however, whether it agrees with that variety, which is described by McCoy, from British specimens, as having constantly two plications in the sinus and three on the fold. De Verneuil describes it, from Russian specimens, as having one to two plications in the sinus, and alludes to American specimens he had seen with three in the same. This being a somewhat variable character, I would be less inclined to regard the very general presence of but a single plication in the middle of the sinus of the form under consideration worthy of notice, if it were not for the fact that this shell also presents a very different physiognomy from that figured by De Verneuil in his work on the Russian fossils, already cited; being much more gibbous, with a decidedly more elevated mesial fold, a proportionally shorter transverse diameter, much coarser plications, and greater general angularity of outline. Indeed, I have seen no forms figured in any foreign work agreeing very nearly with either this or the last described variety. It is true, Mr. Davidson figures an example with but a single strong plication in the bottom of the sinus, and six or seven similar ones on each lateral slope; but still its general rounded outline contrasts strongly with the angularity of our shell, and gives it more nearly the aspect of the variety *lynx*.

Length of a medium-sized specimen, 0.58 inch; breadth, 0.68 inch; convexity, 0.60 inch. The largest individual seen measures 0.65 inch in length, with a breadth of 1 inch, and a convexity of 0.83 inch.

Locality and position: Same as last. I am informed that specimens of this variety generally occur clustered together, as if gregarious in their habits. I believe neither

this nor the last described form ranges into the upper part of the Cincinnati group. The specimens studied and figured were sent to the Smithsonian Institution by Mr. James and Mr. Shaffer, of Cincinnati.

Var. 4. Orthis (Platystr.) acutilirata, Con. (sp.).

Plate 10, figs. 5 *a* to *g*.

Delthyris acutilirata, Con., 1842; Jour. Acad. Nat. Sci., Philad., Vol. VIII., p. 260, pl. XIV., fig. 15.

Orthis inflata,* *O. prolongata*, and *O. annieana*, James, 1871; Cat. Cincinnati Fossils, p. 10.

The typical and most common form of this variety or species (=*O. prolongata* of Mr. James's list) is much extended on the hinge line, which usually terminates in acutely angular, or even mucronate lateral extremities, thus causing the breadth to be sometimes twice, or even, in extreme cases, three times the length of the valves. Between these, however, and others having the hinge not more than one-fifth greater than the length, and only about equaling their greatest breadth (=*O. inflata* of Mr. James's list), there is a completely uninterrupted series of intermediate forms. In all of its variations of proportional length and breadth, however, it agrees in having three, or very rarely four, simple, angular plications in the bottom of the sinus, and four, or very rarely five, on the mesial fold, which latter is always rounded, and but comparatively little elevated. All of its plications are simple, while they are smaller and more numerous than those of any of the other varieties found in this country; there being on each side of the mesial fold and sinus from 11 to 18, making the entire number about 26 to 40 on each valve. The specimens with the lateral extremities most extended have the largest number of plications, probably only because there is more space for them. In these, however, only about the same number reach the beaks as on those less dilated, as a number of the outer ones on the lateral extensions of those more produced laterally, run out on the hinge line without reaching the beaks.

This form becomes quite gibbous with age, the gibbosity being generally most obvious (though not always actually greatest) in the specimens least extended on the hinge line, some of those with the most produced lateral extremities having the middle portions of the valves quite as convex as any of the others of the same antério-posterior dimensions. In these the lateral slopes are very concave, and the anterior lateral margins sinuous and strongly converging toward the front. The mesial

* Not *O. inflata*, Salter.

sinus is well defined, and widens and deepens rather rapidly forward; and, as the mesial fold is proportionally less elevated, the front is often thus caused to be distinctly sinuous in the middle.

Old specimens become quite thickened within, and consequently have the cavity for the muscular attachments in the ventral valve very deep, and similar to that of the var. *lynx*. The surface granulations are usually very beautifully preserved on this variety.

In its much longer hinge line, more produced and acutely angular lateral extremities, more numerous and smaller plications, this form contrasts strongly with the variety *lynx*;* while in these characters and its more depressed and rounded mesial fold, it is even much more strongly distinguished from all of the other known kindred forms of this country.

In its great proportional breadth, and the small size and greater number of its plications, this shell would seem to agree more nearly with the typical European variety *biforata*, than any other we have in this country. Yet it differs in rarely ever having more than three (never more than four) plications in the sinus, instead of five to seven (see McCoy's description of that form). It probably also differs in having its great lateral extension only at and near the hinge line, thus producing acutely angular lateral extremities, as this character is not mentioned in any of the descriptions of that variety I have seen. So far as I have yet observed, no form exactly corresponding to this has been figured from any foreign locality; and it is the most strongly marked type of the group yet known in this country. I am much inclined to think it ought to be separated specifically from all the other forms here noticed under the general name *biforata*, not only on account of the differences mentioned, but because it is confined to one horizon; while all of the others, excepting the var. *lynx*, which has a much greater range, belong to lower horizons.

It is a little remarkable that Mr. Conrad's excellent figure and description of this variety, or species, published in the Journal of the Philad. Academy in 1842, should have been entirely overlooked. This probably arose from the fact that he (erroneously, as I must think) mentioned the Falls of the Ohio as the locality from which his type was obtained. Finding that his figure agrees so exactly with specimens of this shell from Richmond, Indiana, and never having seen any similar shell from the Falls of the Ohio, I wrote to Mr. S. S. Lyon, of Jeffersonville, Indiana, who has long been familiar with the fossils of that locality, asking him if he

* It shades off, however, toward that variety through the individuals least extended on the hinge (*O. inflata*, James), which differ from var. *lynx*, mainly in their more numerous and smaller plications.

had ever found this form at the Falls of the Ohio; and he wrote back that he had never seen such a shell there, or in any of the collections from that locality, and could not believe that it occurs there. I then sent one of the Richmond specimens to Mr. Conrad, and he wrote back that it is, beyond all question, the form figured and described by him under the name *Delthyris acutilirata*.

It is worthy of note that in the same paper in which Mr. C. described this form, he also figured *Rynchonella capax*, from Richmond, Indiana; so that it is evident he had at the same time before him collections from that locality, and it is probable that he was led to cite the Falls of the Ohio, instead of Richmond, by some accidental confusion of labels, or by a slip of the pen.

Length of a moderate-sized, laterally extended specimen, 0.76 inch; breadth, 1.53 inches; convexity, 0.77 inch. Some examples are proportionally more extended on the hinge line, and others much less.

Locality and position: Richmond, Ind., and Clinton, Warren and some of the adjoining counties of Ohio, in the upper part of the Cincinnati group. Not found at Cincinnati or elsewhere so low in the series.

Genus RHYNCHONELLA, Fischer de Waldh., 1809.

(Mem. Soc. Imp. Mosc. II.)

Rhynchonella dentata, Hall.

Plate 11, figs. 3 *a*, *b*, *c*, *d*.

Atrypa dentata, Hall, 1847; Palæont. N. Y., Vol. I., p. 148, pl. XXXIII., figs. 14 *a*, *b*, *c*. *Rhynchonella dentata*, Hall, 1859; Regents' 12th Ann. State Cab. Report, p. 65; James (1872), Cat. Lower Sil. Fossils, Cincinnati Group, p. 11.

Shell rather small, trigonal-sub-globose, generally slightly wider than long, and usually, in adult examples, quite convex; posterior lateral margins nearly straight, or a little convex in outline, and converging to the beaks at nearly a right angle; anterior lateral margins rounded or sub-angular; front usually a little sinuous, as seen in a direct view of either valve.

Dorsal valve more convex than the other, particularly in the anterior central region, where it is often very prominent, being elevated in the form of a distinct mesial ridge that is divided into two plications by a central furrow; lateral slopes rounding off more or less abruptly, and each occupied by from four to five simple, rather angular radiating plications; beak strongly incurved.

Ventral valve (as seen in a side view) somewhat strongly arched from beak to front, or more or less compressed in the central region, and

abruptly curved up at the front and beak; mesial sinus commencing small near the beak, and widening and deepening (with sloping sides and a single central plication) to the front, where it equals about one-half the entire breadth, and terminates a more or less produced, subtrigonal marginal projection, curved up nearly at right angles to the plane of the valve, and fitting into a corresponding sinus in the edge of the same; lateral slopes generally quite abrupt from the edges of the mesial sinus, and each occupied by about five simple sub-angular plications; beak incurved, but not so closely upon that of the other as to conceal the small foramen under its apex.

Surface of both valves with the plications continued to the points of the beaks, and imparting to the interlocking anterior margins a sharply zig-zag outline; while on well-preserved specimens, very fine, obscure lines of growth may be seen, by the aid of a magnifier, crossing the plications and furrows between them, parallel to the zig-zag anterior and lateral margins; though these lines are usually nearly or quite obsolete, excepting near the front.

Length of a rather large, well-developed, gibbous specimen, 0.51 inch; breadth of do., 0.55 inch; convexity, 0.67 inch. Some individuals are proportionally more convex, and others less.

The specimens of this shell before me are generally larger, and often more convex, than the typical form (or at least than the figured specimen) of the New York species; but, otherwise, they seem to agree quite well with the figures and description of the same. They are, however, quite as much, or even more, like some varieties of *R. diodonta*, Dalman, as illustrated by Mr. Davidson in his Monograph of the British Silurian *Brachiopoda*, pl. XXI. Yet they generally differ in being straighter or more sinuous in front, and rather more gibbous; while they are decidedly less variable in the number of plications. Among a large number of specimens, I have never seen one with more than a single plication in the mesial sinus, and two on the mesial fold, though there is very rarely a rudimentary plication a little raised on each side of the usual two forming the fold of the dorsal valve; while a large majority of them have only four or five on each lateral slope of each valve; and where we find one or two more, it is only by counting mere rudimentary lateral ones, so slightly developed as scarcely to attract attention.

Locality and position: The New York specimens are referred doubtfully to the Trenton group. Those here under consideration came from Richmond, Indiana, and from some of the adjoining portions of Ohio, where they are rather common in the upper part of the Cincinnati group. I am indebted to Mr. James, of Cincinnati, for some fine specimens of this species.

Rhynchonella capax, Conrad (sp.).

Plate 11, figs. 6 *a* to *f*.

Atrypa capax, Conrad, 1842; Jour. Philad. Acad. Sci., Vol. VIII., p. 264, pl. XIV., fig. 21.
Atrypa increbescens, Hall, 1847; Palæont. N. Y., Vol. I., p. 146, pl. XXXIII., fig. 13 *a–y*.
? Atrypa subtrigonalis, Hall, 1847; Palæont. N. Y., Vol. I., p. 145, pl. 33, fig. 12.
? Rhynchonella subtrigonalis, 1859; Regents' 12th Ann. State Cab. Report, p. 65.
Rhynchonella increbescens, Hall, 1859; Regents' 12th Ann. State Cab. Report, p. 66; and in 13th do. (1861), p. 66; also (1862) Wisconsin Geological Report, p. 55.
Rhynchonella capax, Billings, 1862; Palæozoic Fossils of Canada, Vol. I., p. 142.

Shell attaining about a medium size, varying with age from compressed sub-trigonal to sub-globose, old examples being often more convex than their diameter in any other direction; posterior lateral margins somewhat straightened and converging to the beaks at about a right angle in young shells, but becoming more rounded in the adult; lateral margins rounding to the front, which is more or less distinctly sinuous, or nearly straight in the middle.

Dorsal valve generally a little more convex than the other, most prominent in the middle, and rounding abruptly, or sloping more gently, from the central region in all directions; the more elevated part forming anteriorly a depressed mesial ridge that is nearly flat, and occupied by four plications on top, and rarely continues two-thirds of the way to the strongly incurved beak; while on young or compressed individuals, it is faintly marked even anteriorly; lateral slopes each occupied by four to seven or eight simple angular plications.

Ventral valve with its beak abruptly pointed, and very strongly incurved upon that of the other valve, in adult shells, but less distinctly curved, and showing a small opening under its apex, in young examples; mesial sinus deep and well defined in gibbous specimens, and less so in the young or more compressed forms, never quite reaching the point of the beak, and always having three simple, rather angular plications in the bottom, that extend, like the others, to the apex of the beak, in well-preserved specimens; lateral slopes each occupied by from five to seven simple plications.

Entire surface of both valves marked by numerous very regular, strongly zig-zag, prominent, sublaminar marks of growth, that become nearly or quite obsolete, sometimes, on old examples.

Length of a medium-sized, moderately gibbous individual, 0.75 inch; breadth, 0.81 inch; convexity, 0.66 inch.

This species varies considerably in form, but generally increases regu-

larly in convexity with age, some of the larger individuals becoming extremely gibbous. It varies comparatively little, however, in the number of plications, though the younger individuals usually show the marks of growth more distinctly than the largest and most convex ones. Large examples have the substance of the shell often much thickened within, on each side of the umbonal region of the ventral valve, with a deep angular impression between, for the muscular scars, and a deep, narrowly-rounded, rostral cavity, which makes the beak of this valve very thin, so that its apex is often broken away in such a manner as to appear as if there had been a perforation there. But many well-preserved, adult specimens, show that this is not the case, though there was always a small opening under the immediate apex, in young shells, which became closed, by the close incurving of the beak upon that of the other valve, with age. The hinge teeth of the ventral valve are quite prominent, and between these and the beak there is a concave space on each side of the rostral cavity, that sometimes presents the appearance of a very restricted concave area; but it seems to be the result of the truncation, as it were, of the thickened margin on each side of the rostral cavity, to form a space for the strongly incurved beak of the opposite valve. The cardinal process of the dorsal valve is moderately prominent, and so deeply divided as to present the appearance of two diverging teeth, with a slender, slightly raised ridge or line in the bottom of the division between; while a more or less defined mesial internal ridge extends forward nearly to the middle of the interior surface of the valve, and just outside of these divisions of the cardinal process, a deep pit is seen on each side, for the reception of the teeth of the other valve.

It is a little surprising that Mr. Conrad's name, *capax*, was not retained for this shell, when there is not the slightest reason to doubt that his name was proposed for a gibbous example of the same species. He gives Richmond, Indiana, as the locality, at which place it is well known to occur in great numbers, while no other similar form has been found there. I have now before me numerous specimens collected at Richmond, by Mr. Case and myself, some of the larger, more gibbous examples of which, that have lost their marks of growth, agree exactly with Mr. Conrad's figure.

Locality and position: Upper part of the Cincinnati group, at Oxford and other localities in Ohio; Richmond, Madison, and elsewhere in Indiana; Maysville and Frankfort, Kentucky, as well as at many other localities of the West. It also occurs at the same horizon, and in the Trenton limestone, in New York. Prof. Hall gives Cincinnati as one of its localities, in the first volume Palæont. N. Y., but it does not occur there, nor within twenty miles of that city, I am informed by Prof. Orton.

Genus ZYGOSPIRA, Hall, 1862.*

(Regents' 15th Ann. State Cab. N. H. Report, p. 154.)

Zygospira modesta, Say (sp.).

Plate 11, figs. 4 *a, b, c, d.*

Producta modesta, Say; MS.
Atrypa modesta, Hall, 1847; Palæont. N. Y., Vol. I., p. 141, pl. XXXIII., fig. 15.
Genus? related to *Leptocostia?* Hall, 1859; Regents' 12th Ann. State Cab. Report, p. 66.
Zygospira modesta, Hall, 1862; Regents' 15th Report State Cab., p. 154.

Shell small, rather depressed, nearly plano-convex, sub-orbicular, or sometimes a little wider than long; posterior lateral margins often slightly straightened and converging to the beaks at an obtuse angle; lateral margins more or less rounded; front rounded, or sometimes a little straightened, or very slightly sinuous at the middle.

Dorsal valve with a rather shallow, undefined mesial sinus of moderate breadth at the front, but becoming rapidly narrower, and less impressed posteriorly, so as often to die out before reaching the umbo; surface on each side of the sinus gently convex centrally, and sloping gradually to the lateral margins; beak but slightly prominent and incurved.

Ventral valve, with a low mesial ridge, corresponding to the sinus of the other valve, excepting that it is generally most prominent near the middle, and somewhat depressed anteriorly; while on each side of the ridge the slopes are distinctly compressed; beak small, abruptly pointed, projecting beyond that of the other valve, and rather distinctly arched; but not so closely incurved as to conceal the small fissure, which seems to be closed below by a deltidium, that leaves a minute aperture above, just under, or extending to, the apex; margin on each side of beak carinated, so as to give the appearance of a kind of false cardinal area.

Surface of each valve ornamented by about 16 to 18 small, simple, radiating plications, of which about three to five near the front of the dorsal valve occupy the mesial sinus, the middle one being usually a little the largest; while on the ventral valve about four of the largest occupy the mesial prominence, the furrow between the middle two being generally a little larger and deeper than the others; marks of growth undefined, or extremely minute and obscure.

Length of a mature, moderately large specimen, 0.26 inch; breadth, 0.30 inch; convexity, 0.15 inch.

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* As I have elsewhere stated, this group seems to be closely related to *Anoplotheca* of Sandberger, 1856.

This neat, well-marked little shell is very abundant, and easily recognized. Its most marked characters are its small size, and sub-plano-convex form, with a shallow mesial depression in the dorsal valve, and a corresponding mesial elevation on the ventral valve, provided with a slightly larger and deeper furrow along its middle than those separating the other plications.

Locality and position: In New York, this shell is said to have been found only in the Utica Slate, or upper part of the Trenton Limestone, at Turin, Lewis county. In Ohio, it ranges from the lower part of the Cincinnati group, at that city, to the top of the series, and into the Clinton group. It occurs in the upper beds of the Cincinnati group at Richmond, Ind., and Oxford and many other localities in Ohio; also at Madison, Ind., and in the corresponding beds in Kentucky, as well as at many other western localities.

Zygospira Cincinnatiensis, James.

Plate 11, figs. 5 *a*, *b*, *c*.

Zygospira Cincinnatiensis, 1871; Catalogue Lower Sil. Foss., Cincinnati Group, p. 11.

This variety or species differs from the last, in its larger size, greater proportional breadth, more prominent mesial elevation, with a larger and deeper sulcus along its middle, and in the deeper mesial sinus of its dorsal valve, and the more spreading character of its lateral plications. Its plications likewise differ in being proportionally coarser, and more angular, and more frequently show a disposition to bifurcate, particularly those on the sides of the mesial elevation of the ventral valve, and within or near the mesial sinus of the dorsal valve. Its lateral margins are likewise generally more compressed; and the beak of its ventral valve rather more strongly incurved.

Under a strong magnifier, in a favorable light, extremely minute, regular, and closely crowded concentric striæ may sometimes be seen on the sides of the plications, and other protected parts of the shell. These are similar to those sometimes seen on the last, but more distinct.

Although this is possibly a distinct species from the last, it would, I should think, be rather difficult to distinguish young or small examples of it from that shell. Hence I am inclined to think that it may be only a robust variety of the same.

Length of one of the largest examples, 0.41 inch; breadth, 0.52 inch; convexity, 0.25 inch.

Locality and position: Cincinnati group, at an elevation of 250 feet above low-water mark, Cincinnati, Ohio. I am indebted to Mr. James, of Cincinnati, for some fine examples of this form.

Zygospira Headi, Billings, (sp.).

Plate 11, figs. 1 *a, b, c, d.*

Athyris Headi, Billings, 1862; New Sp. Lower Sil. Fossils, p. 147, figs. 125 *a, b*, 126 *a, b*, and 127 *a, b*; also Geol. Canada, Palæozoic Foss., Vol. I., p. 147, with same figures; James (1871), Cat. Lower Sil. Foss., Cincinnati Group, p. 11.

? Atrypa ? Headi, var. Anglica, Davidson, 1867; Monogr. Brit. Foss. Brach., part VII., No. 2, pl. XXII., figs. 1–7.

Zygospira Headi, Hall, 1872; Plate 13, figs. 23 and 25, of illustrations accompanying a re-issue of a paper entitled "Notice of New and Little Known *Brachiopoda*," etc., dated March, 1871.

Shell attaining a medium or rather large size, longitudinally oval, the front being regularly rounded, and the lateral margins more broadly rounded, or sometimes slightly straightened along the middle; valves both rather evenly convex. Dorsal valve a little less convex than the other, its greatest prominence being near the middle, but without any traces of a mesial ridge; beak very short and incurved. Ventral valve with its greatest convexity behind the middle; mesial sinus almost obsolete, or only consisting of a slight flattening along the middle of the anterior slope, on each side of which the lateral slopes are sometimes very slightly compressed; beak only moderately prominent, obtusely pointed, and strongly incurved upon that of the other valve, while on each side of it a slight carination extends laterally, so as to give somewhat the appearance of a false area. Surface ornamented by fine, even, simple, radiating striæ. Interior unknown.

Length of a medium-sized specimen, 0.61 inch; breadth, 0.52 inch; convexity, 0.34 inch.

I have seen no specimens showing the interior of this shell, though one of those before me shows the hinge of the ventral valve. This has a rather prominent, compressed, oblique tooth on each side of the triangular fissure, which latter extends up nearly to the point of the beak. This fissure was doubtless closed below by a deltidium, so as to leave a minute, round perforation at the end of the beak.

Mr. Billings evidently had no specimens of this shell showing its interior at the time he described it, as he neither figured nor described its internal characters. He afterwards, however, wrote to Mr. Davidson that he had determined that it has internal spires arranged as in *Atrypa*. At a later date, Prof. Hall illustrated one of these appendages of this shell, showing it to have the paucispiral character, and to be accompanied

by other peculiarities characterizing his group *Zygospira*, which may be only a sub-genus or section of the genus *Atrypa*.

Locality and position: Upper part of the Cincinnati group, in Clinton county, Ohio, Madison, Indiana, etc. Mr. Billings's typical specimens were from the equivalent beds of the Cincinnati group, on the south shore of the St. Lawrence, opposite Three Rivers. I am indebted to Mr. James, of Cincinnati, for the only specimens of this species I have seen, as well as for a knowledge of its position in these western rocks.

Mr. Davidson refers doubtfully to this species, an English shell, from the Caradoc Limestone. It is a larger, more robust form, with a more decided sinus in the front of the ventral valve, and may be specifically distinct.

Genus RETZIA, King, 1850.

(Permian Fossils of England, p. 137.)

Retzia (Trematospira) granulifera, Meek.

Plate 11, figs. 6 *a*, *b*, *c*, *d*, *e*.

Retzia (*Trematospira*) *granulifera*, Meek, 1872; Proceed. Acad Nat. Sci., Philad., p. 318.
Compare *Retzia Salteri*, Davidson (1848), as illustrated in his Monogr. British Sil. Brach., pl. XII., figs. 21 and 21 *a*, *b*.

Shell transversely oval, the length being about four-fifths the breadth, moderately convex, the convexity of the two valves being very nearly equal; lateral margins rather narrowly rounded in outline; front and anterior lateral margins broadly rounded, or perhaps the former sometimes straight or slightly sinuous in outline in the middle; cardinal margin nearly straight on each side, and sloping at an angle of about 140° from the beaks toward the lateral extremities.

Dorsal valve nearly evenly convex, its greatest prominence being slightly behind the middle; provided with about thirteen simple, angular, radiating plications or costæ, five of which on the middle are smaller than the others (the middle one being smallest and not continued to the beak), and forming together a very low flattened mesial elevation, scarcely rising above the general convexity; beak rather strongly incurved.

Ventral valve of much the same form as the other, excepting that its beak is somewhat more prominent, perforated,* and incurved upon that

* The immediate point of the beak of the ventral valve seems to be slightly broken in the specimen; though it has the appearance of having been naturally perforated before receiving the slight injury.

of the other valve; while two of its middle costæ are much smaller than the others, and the first one on each side of these is intermediate in size between the smallest central ones and the largest on the lateral slopes; these four smaller ones being a little depressed, so as to form a shallow mesial sinus that is not continued to the beak. Crossing all of these plications of both valves are numerous fine lines of growth; while the entire surface, as seen under a magnifier, is occupied by minute projecting points, like grains of sand, and between these, a higher magnifying power shows the whole surface to be very minutely and regularly punctate.

Length, 0.37 inch; breadth, 0.50 inch; convexity, 0.27 inch.

Until the distinctions between the genus *Retzia* and the proposed genus *Trematospira* (if any exist) are better defined, and the interior of the species here described can be determined, it is not possible to say to which of these groups it most properly belongs.

Specifically, however, it seems to be closely allied to *Trematospira gibbosa* of Hall, from the Hamilton group. Yet it differs not only in having two to three more plications on each valve, but also in having five, instead of three, a little raised, to form the mesial fold of the dorsal valve (the middle one being also much smaller), and four depressed, to form the mesial sinus (the middle two being much smaller than the others). It so nearly resembles the New York form, however, that I should almost be inclined to suspect that it might be only a variety of the same species, if it were not found at so much lower a horizon. It must be very rare, as I have only heard of the single typical specimen being found.

After publishing a description of this species, and since writing the foregoing, I have observed that it is even more closely allied to the English species *Retzia Salteri* of Davidson, than to the American form with which I have compared it above. Indeed, it so very nearly resembles Mr. Davidson's figure, that I strongly suspect that it will be found to be specifically identical. As I have already proposed a distinct name for it, however, I prefer to retain it under the same, until it can be compared with specimens of the English shell.

Locality and position: Cincinnati group of the Lower Silurian, at the base of the series exposed at Cincinnati, Ohio. Mr. Dyer's collection.

Genus PHOLIDOPS, Hall, 1860.*

(13th Report of Regents, p. 92.)

Pholidops Cincinnatiensis, Hall.

Plate 5, figs. 2 *a*, *b*.

Pholidops Cincinnatiensis, Hall, 1872; Discr. New Sp. Fossils, pl. 3, fig. 10.

Shell small, ovate in outline. Larger valve about one-fifth longer than wide, with height one-third to one-fourth the breadth. Apex obtuse, near half way between the middle and the larger end. Anterior end narrowly rounded, posterior end somewhat more broadly rounded, or almost sub-truncate. Surface ornamented by six or seven sub-imbricating marks of growth. Smaller valve unknown.

Length, 0.14 inch; breadth, 0.12 inch; height of larger valve, 0.04 inch.

This species is very closely allied to *Pholidops ovatus* from the Upper Silurian Shaly limestone, from which it seems only to differ in having a less number of imbricating laminæ of growth; the figure of that species showing about twelve of these laminæ, while in the Cincinnati species there are only about seven or eight. Such a difference would scarcely warrant a separation, if it were not for the decidedly different horizons at which these forms occur.

Locality and position: Cincinnati group of the Lower Silurian, about three hundred feet above low-water mark of the Ohio, at Cincinnati, Ohio. Mr. James's collection.

LAMELLIBRANCHIATA.

Genus AMBONYCHIA, Hall, 1847.

(Palæont. N. Y., Vol. I., p. 163.)

Ambonychia costata, James.

Plate 12, figs. 5 *a*, *b*, *c*.

Ambonychia costata, James, 1871; Catalogue L. S. Fossils, Cincinnati Group, p. 13 (without a description).

Shell of about medium size, moderately oblique, sub-ovate, very thin, rather compressed, the left valve being apparently a little more convex than the other; basal margin regularly rounded; posterior margin

* Mr. Davidson thinks this not distinct from *Pseudocrania* of McCoy, 1859; but it seems to me to differ sufficiently from Prof. McCoy's type to require a distinct generic name.

apparently broadly convex in outline; anterior side truncated, or a little concave above, and rounding into the base below; beaks pointed terminal, rather oblique, and rising moderately above the cardinal margin; umbonal slopes not angular, or very prominent; hinge line straight, short, and ranging at an angle of about 60° to the longer axis of the valves. Surface of both valves ornamented by about twenty simple, depressed, radiating costæ (narrower than the flat interspaces) and fine concentric striæ of growth.

Length, measuring obliquely from the points of the beaks to the most prominent part of the basal margin, about 1.63 inches; anterio-posterior diameter, about 1.10 inches; convexity of the two valves, 0.54 inch.

This form will be readily distinguished from the other known species by its small number, and more widely separated costæ, and rather compressed, narrow form. It also differs from *A. radiata*, in having its costæ separated by flat interspaces, instead of "regularly concave grooves, narrower than the radii."

Locality and position: Cincinnati group, 350 feet above low-water mark, at Cincinnati, Ohio. Mr. U. P. James's collection.

Ambonychia (Megaptera*) alata, Meek.

Plate 11, fig. 9; and 12, fig. 10.

Megaptera Casei, ? James, 1871; Cat. Fossils Cincinnati Group, p. 13 (not of Meek and Worthen).

Ambonychia (*Megaptera*) *alata*, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 319.

Shell attaining a moderately large size, sub-trigonal in general outline, compressed posterio-dorsally, and more convex in the umbonal and

* In first proposing the name *Megaptera*, for these great winged species, in 1866, Mr. Worthen and the writer were not aware that this name had been previously used by Dr. Gray for a genus of Whiles. Naturalists do not agree in regard to the propriety of retaining the same name for different genera, or sub-genera, in such cases. Where the groups belong to the same class, nearly all agree that only the name first published can stand; but where they belong to different classes or sub-kingdoms, some would retain both names; while others would change the later name, even where the genera belongs to a different class, sub-kingdom, or kingdom of nature. In case it should be thought desirable to substitute another name for this group, as typified by *M. Casei*, and the species here described, I have proposed to call it *Opisthoptera*. (Proceed. Acad. Nat. Sci., Philad., Feb'y, 1872, p. 319.) As yet very little is known in regard to the hinge of these shells, consequently we have not the means of determining whether they should be ranged as a sub-genus under *Ambonychia*, or as a distinct genus, though I at present incline to the former opinion.

anterio-central regions; umbonal slopes ranging at an angle of about fifty degrees below the hinge line, and broadly rounded; hinge line straight, very nearly or quite equaling the greatest anterio-posterior diameter of the valves, and ranging nearly at right angles to the anterior side of the same; posterior alation very large, not separated from the swell of the umbonal and central regions by any defined sulcus, slightly rounded at its immediate extremity above; posterior margin faintly sinuous a little below its intersection with the hinge margin above, thence sloping forward and downward, and finally rounding into the regularly rounded base; anterior side more or less concave and nearly vertical above, but rounding regularly into the base below; beaks terminal, rather pointed, rising little above the hinge line, and directed a little obliquely upward and forward, with more or less inward curvature.

Surface ornamented by about twenty-four to twenty-eight simple, strong, radiating costæ to each valve, that are nearly equal in breadth to the furrows between; those on the central portions of the valves passing nearly straight from the beaks obliquely to the posterior basal margins, those on the anterior side curving more or less forward below, and those near the cardinal margin curving a little upward behind, in some examples. Crossing all of these costæ, and the furrows between, are numerous fine, crowded lines, and at regular, distant intervals, a few strongly defined, imbricating marks of growth, that curve parallel to the basal and posterior margins.

Height, 2.30 inches; breadth, 2.20 inches; convexity, about 0.80 inch.

This species was referred with a mark of doubt, by Mr. James, to *Megaptera Casei* of Meek and Worthen, but, after a comparison of these shells, I can find no reason for doubting that they are really distinct specifically, the *M. Casei* being merely marked by very numerous alternating larger and smaller radiating striæ, while *M. alata* is ornamented with large, strong, radiating ribs. *M. Casei* also differs in having its umbonal slopes distinctly angular, instead of broadly and evenly rounded, as in the species under consideration; while its ventral margin is angular in outline at the termination of the umbonal ridge, instead of being rounded.

Its marks of growth also show that the extremity of its wing was rather acutely pointed, instead of being a little rounded, as in the one here described.

Locality and position: Clinton County, Ohio, in upper part of the Cincinnati group of the Lower Silurian. Mr. James's collection.

Ambonychia (Megaptera) Casei, M. and W.?

Plate 11, fig. 8.

Ambonychia (*Megaptera*) *Casei*, Meek and Worthen, 1866; Proceed. Chicago Acad. Sci., Vol. I., p. 22; and Illinois Geological Report, Vol. III., p. 337, pl. 4, figs. 9 *a*, *b*.

The only specimen of this shell I have seen, agrees so nearly in form and general appearance with the type of the species *Casei*, that I scarcely feel warranted in regarding it as a distinct species. It presents some differences in the nature of its costæ, however, that may possibly be found to be of specific importance, if additional specimens should show them to be constant. In the typical specimens of *A. Casei*, the costæ are small, and rather closely arranged, or sometimes alternately a little larger and smaller; while in that here under consideration, they are of nearly the same size as those of the type, for about one-third to one-half their length, but separated by wider spaces than their own breadth, after which they bifurcate, or divide into three, with some other small ones intercalated between, so that the whole become much smaller near the free margins, though not exactly equal.

Should this character be found to be constant, and sufficiently distinct from the typical specimens found at Richmond, to render it desirable to designate the Cincinnati type by a different name, it might be called *A. fissicosta*.

Locality and position: Cincinnati group, Cincinnati, Ohio.

Genus CYPRICARDITES, Conrad, 1841.

(Ann. Report Palæont. N. Y., p. 51.)

Cypricardites Sterlingensis, M. and W.? (sp.).

Plate 11, figs. 12 *a*, *b*.

? Dolabra Sterlingensis, Meek and Worthen, July, 1866; Proceed. Acad. Nat. S., Philad., p. 260; Illinois Geological Report, Vol. III., p. 339, pl. 4, figs. 10 *a*, *b*, *c*.

Shell obliquely rhomboidal, or rhombic-subcordate, being cordate in outline as seen in an anterior or posterior view, and more or less rhomboidal as seen from either side. Posterior margin very obliquely truncated, with a long slope; posterior basal extremity produced and very narrowly rounded; basal margin ascending forward with a moderately convex curve, and rounding upward into the very short, more or less

rounded anterior margin. Hinge line short, ranging at an angle of about 45° to 50° from the umbonal axis. Umbonal ridges very prominent, or sub-angular, from the posterior side of the beaks obliquely backward and downward to the posterior basal extremity; area above and behind this ridge, flattened in each valve; and that below and in front of it, more or less convex. Surface unknown. Posterior muscular impression large, nearly circular, faintly marked, and placed near the middle of the posterior truncated margin. Anterior muscular scar smaller, more oval, and placed nearly against the anterior margin.

Length, measuring obliquely from the most prominent part of the front to the posterior basal extremity, 2.14 inches; height, at right angles to the hinge, 1.75 inches; convexity, 1.25 inches.

I am not sure that this is the form figured in the Illinois Report, from which it seems to differ somewhat in outline. As the typical specimen of that species, however, is a cast of the exterior, and that here illustrated is a cast of the interior, the differences of form may be due to that fact. In some respects, it resembles more nearly *Cyrtodonta Hindi* of Billings, to which species perfect specimens might possibly show it to belong; although in other characters it *seems* to be too distinct from that form to be the same species. That it belongs to the same genus, however, there can scarcely be any doubt.

In regard to which of the several generic names, *Cypricardites*, *Dolabra*, or *Cyrtodonta*, should be retained for such shells, it is not easy to decide, in the present state of our knowledge of their characters. The genus *Cypricardites*, as used by Mr. Conrad, was made to include a rather wide range of forms, now known to belong to several distinct genera, the hinges of which were unknown to him. From the sketch left by him with Prof. Hall, of the form from which his description of the hinge was evidently drawn up, it seems scarcely to admit of doubt, that it really belongs to the same genus called *Cyrtodonta*, by Mr. Billings, at a later date. Although Mr. Billings was entirely excusable for not perceiving the probable identity of his shells with Mr. Conrad's type (the figure of which had not at that time been published, while the genus had been entirely ignored in quarters where there should not have been the slightest doubt in regard to it), the inflexible rules of priority will, I think, compel us to adopt Mr. Conrad's name, *Cypricardites*, for such shells.

Cyrtodonta Hindi, and the form here under consideration, differ, however, in physiognomy, from both the typical forms of *Cypricardites* and *Cyrtodonta;* so that it is barely possible that they may belong to a differ-

ent group from that to which the names just mentioned were applied. If so, however, I should think that they would more probably fall into McCoy's genus *Dolabra*, some forms of which they nearly resemble. As originally proposed by Prof. McCoy, the genus *Dolabra* included two generic types, one of shells like that here under consideration, and that for which Prof. King afterwards proposed the name *Schizodus;* so that if the name *Dolabra* is to be retained at all (and I think the rules of nomenclature would certainly require that it should be retained), it would seem to apply to the group to which the shell here described, and *Cyrtodonta Hindi*, belong. But the probability is, that such forms have essentially the hinge characters of *Cypricardites*, in which case they will probably have to be ranged under that older name. At any rate, the specimen we have figured, of the form here under consideration, shows, at the point marked (*t*) in the figure, impressions of the anterior ends of one or two posterior lateral teeth, like those in *Dolabra angustata;* but also equally ike those of *Cyrtodonta* or *Cypricardites.*

Locality and position: Richmond, Indiana, in the upper part of the Cincinnati group. Mr. L. B. Case's collection.

Cypricardites? carinata, Meek.

Plate 12, figs. 6 *a*, *b*.

Dolabra? carinata, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 326.

Shell small, rhombic-cordate, very convex along the oblique umbonal slopes; posterior margin apparently obliquely truncated; posterior basal extremity more or less angular in outline; basal margin rounding and ascending obliquely forward from the posterior basal angle; anterior side extremely short, or with its margin descending and curving backward into the base, from immediately in front of the beaks; hinge line short, and a little inflected so as to form a kind of small area or escutcheon behind the beaks; beaks prominent, rather oblique, nearly terminal, strongly incurved or sub-spiral, and distinctly compressed anterio-posteriorly, so as to be sharply keeled on top, the keel being continued as a less angular umbonal ridge backward and downward to the posterior basal extremity; flanks in front of the umbonal ridge evenly convex; while the space above and behind it, near the beaks, is somewhat concave. Surface only showing obscure traces of lines of growth. Hinge and interior unknown.

Length, measuring obliquely from the posterior basal angle to the most prominent part of umbonal keels, 0.65 inch; anterio-posterior diameter,

measuring parallel to the hinge line (the specimen being defective behind), 0.40 inch; convexity of the united valves, 0.50 inch; length of hinge, about 0.30 inch.

The only specimen of this species I have seen, has lost, by erosion, some portions of the posterior margin, so as to leave doubts in regard to its exact outline; though it has the appearance of having been, when entire, more or less truncated behind. The most remarkable features of the species are its prominent sub-spiral and very strongly carinated beaks, short hinge, and nearly obsolete anterior side. Its front margin seems to have been a little gaping, and the posterior side may have been more or less so, though the specimen is not in a condition to show whether or not this was the case.

In originally referring this little shell to *Dolabra*, I appended a mark of doubt after the generic name, and also distinctly stated that I really had very little idea that it belonged properly to that group, but suspected that it might be found to belong to an undescribed genus, when its hinge characters could be known, in which case I suggested that *Rhynchotropis* would be a good name for it.

Its hinge still remains unknown, and it is only here placed provisionally under the name *Cypricardites*, from its apparent relations to the last, which it is probable will be found not to differ essentially in its hinge characters from the typical forms of that genus.

Specifically, it will be readily distinguished from the foregoing form, not only by its much smaller size, but by its decidedly keeled umbonal slopes, more spiral beaks, and shorter anterior margin. It must be very rare, as I have only seen the single typical specimen among all the collections from this horizon.

Locality and position: Cincinnati group of the Lower Silurian, at Cincinnati, Ohio, where it was found at a horizon of about 175 feet below the tops of the hills. Mr. Dyer's collection.

Genus MEGAMBONIA, Hall, 1859.

(12th Ann. Report Regents, p. 12.)

Megambonia Jamesi, Meek.

Plate 12, figs. 9 *a*, *b*.

Megambonia? Spinneri? James, 1871; Cat. Fossils Cincinnati Group, p. 12 (not *M. Spinneri*, Hall).

Megambonia Jamesi, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 321.

Shell attaining a rather large size, a little obliquely sub-ovate in general form, rather convex, the most gibbous part being somewhat

above, and in front of, the middle, more or less abruptly cuneate posteriorly and below; basal outline regularly rounded; posterior margin rounding into the base, and ascending with a convex curve, and forward inclination, to the posterior extremity of the hinge, which is not in the slightest degree alate behind; anterior margin rounding into the base below, and slightly sinuous under the lobe-like protuberance, or rudimentary wing, above; which latter is convex, slightly more prominent than the margin below, and defined from the swell of the umbonal regions on each side by an oblique sulcus, extending to the hinge margin in front of each beak; hinge equaling about two-thirds the anterio-posterior diameter of the valves; beak rather prominent, or rising distinctly above the hinge line, but slightly oblique, and distinctly incurved; umbonal slopes broadly rounded; longer axis of the valves a little oblique to the hinge line. Surface ornamented by very regular, rounded, simple and depressed, radiating costæ, a little wider than the furrows between, and numbering about five in a space of 0.30 inch near the middle of the lower margin.

Height about 2.50 inches; anterio-posterior diameter, 2.16 inches; convexity, 1.50 inches.

The only specimen of this species I have seen, is a cast of the exterior, with portions of the ventral and anterior ventral margins broken away. The beak of its right valve projects rather decidedly above that of the left, but I think this is due to accidental displacement of the valves, rather than to any inequality in their size. It shows distinct indications of a well-defined, moderately wide, cardinal area, widest under the beaks, and narrowing to the extremities of the hinge.

Mr. James referred this species, in his list of the Cincinnati fossils, with a mark of doubt, to the Lower Helderberg species, *M. Spinneri* of Hall. But in addition to the rather widely different geological horizons from which these two shells were obtained, they seem to me to differ so materially in form as to be clearly distinct species, even if similarly marked; while the typical specimen of *M. Spinneri* shows no traces of the regular radiating costæ seen on the species here described. It is true that the specimen of that species figured is an internal cast, and ours a cast of the exterior, which might account for the difference of surface characters, but this would not produce the degree of difference in form, obliquity, and general physiognomy. To me it appears to be much more nearly like the typical species *M. cardiiformis*, from the New York Upper Helderberg Limestone; though clearly distinct in having much larger costæ, as well as a wider and more defined cardinal area.

The group *Megambonia* of Hall, 1859, seems, so far as yet known, scarcely

more than sub-generically distinct from the typical forms of *Cypricardites*, Conrad. Mr. Billings thinks it also exactly agrees with the group for which he proposed the name *Vanuxemia*, in 1858, and placed by him as a sub-genus under his genus *Cyrtodonta*, 1858, a species of which, as already stated, seems to be the type of Conrad's *Cypricardites*, 1841. If the name *Vanuxemia* should be retained for the type under consideration, and that group placed as a sub-genus, then the name of our fossil, when written in full, would be *Cypricardites* (*Vanuxemia*) *Cincinnatiensis;* but if *Megambonia* is distinct from *Vanuxemia*, and a sub-genus under *Cypricardites*, then its full name would be *Cypricardites* (*Megambonia*) *Cincinnatiensis.*

Locality and position: Cincinnati group of the Lower Silurian, at Cincinnati, Ohio, about 350 feet above low-water mark of the Ohio river. Mr. U. P. James's collection.

Genus CLIDOPHORUS, Hall, 1847.

(Palæont. N. Y., Vol. I., p. 300).

Clidophorus (Nucülites?) fabula, Hall, (sp.).

Plate 11, figs. 10 *a*, *b*.

Nucula fabula, Hall, 1845; Am. Jour. Sci. and Arts, Vol. XLIII., p. 295.

Shell minute, or very small, transversely sub-elliptic, moderately convex; extremities narrowly rounded, the anterior end being narrower than the posterior; basal margin forming a broad semi-elliptic curve; beaks rather depressed, slightly tumid, and placed a little in advance of the middle; dorsal margin sloping gently from the beaks, the anterior slope being rather less gradual than the other, and, in the cast, a little concave in front of the beaks. Anterior muscular impressions distinctly defined by the internal ridge, which leaves a rather deep furrow just in advance of each beak in casts of the interior.

Length, 0.06 inch; height, 0.03 inch; convexity, about 0.02 inch.

Although the proportions of this little shell do not conform to the literal meaning of the words used in Prof. Hall's description, as these terms are now most generally applied in describing bivalves, I have little doubt that his description was intended for this species. It is scarcely possible, however, to be positively sure of this, as he gave no figure, and but a brief description, with the measurement of only one of its diameters. If by the words "twice as wide as long," he meant that the anterio-posterior diameter is twice the height of the shell, it would apply exactly to the

little shell under consideration; but if he meant the reverse, of course it would not. The terms height, length, and breadth, have been, at different times, and by different authors, variously applied, in describing such shells, and as it is very improbable that Prof. Hall's type is either twice as high, or twice as convex, as its anterio-posterior diameter, it is almost certain that he either inadvertently reversed the words "long" and "wide," or that he viewed the anterio-posterior diameter as the breadth, and the height as the length, as is even yet done by some.

Locality and position: Near the middle of the Cincinnati group, at the tops of the hills at Cincinnati, Ohio. Specimens studied sent by Mr. Miller, of Cincinnati, to the Smithsonian Institution.

Genus TELLINOMYA, Hall, 1847.

(Palæont. N. Y., Vol. I., p. 151).

Tellinomya? obliqua, Hall (sp.).

Plate 11, figs. 11 *a*, *b*, *c*.

Nucula obliqua, Hall, 1845; Am. Jour. Sci. and Arts, Vol. XLIII., p. 292.

Shell very small, compressed, sub-circular, approaching sub-quadrangular; height and breadth about equal; anterior margin short and rounding into the rounded basal margin; posterior margin sub-truncated, or more or less rounded; beaks elevated, nearer the anterior margin; dorsal margin sloping from the beaks, the anterior slope being the more abrupt, and the margin behind the beaks straighter, more compressed and sharper; surface smooth; internal casts showing the muscular impressions to be comparatively rather distinct. Hinge unknown.

Length, 0.06 inch; height slightly less; convexity, 0.03 inch.

Prof. Hall's description of his *Nucula obliqua* is so very brief (about three lines) that it is impossible to be sure that the little shell here described is the same, especially as he gave no figure. As it is from the same locality and position, however, and agrees better with his description than any form I have seen from these rocks, it is probably his species. Should it prove to be distinct, however, it may take the name *T. microsperma*, which would probably not, in any event, be superfluous, since Portlock had named a little Silurian shell *Arca obliqua*, in 1843, that would apparently fall into the same genus with this, if the hinge of this shell (which I have not clearly seen) is crenulated.

Locality and position: Same as last. Specimens from Mr. Miller.

Genus ANODONTOPSIS, McCoy, 1851.

(Brit. Pal. Foss., p. 270.)

Anodontopsis? Milleri, Meek.

Plate 12, figs. 1 *a*, *b*, *c*, *d*.

Anodontopsis? Milleri, Meek, 1871; Am. Jour. Sci. and Arts, Vol. II., p. 297 (issued Sept. 29th for Oct., 1871).

Shell ovate, rather compressed, or moderately convex, the greatest convexity being a little above and slightly in advance of the middle; extremities more or less narrowly rounded, basal margin longitudinally semi-elliptic in outline, the most prominent part being near the middle; cardinal margin sloping from the beaks at an angle of 130° to 135°, and rounding into the lateral margins, the anterior slope being more abrupt than the other; beaks depressed, and somewhat obtuse, not very convex, placed more than one-third the length of the valves from the anterior end. Surface smooth, or only with obscure lines of growth.

Length of a medium-sized adult specimen, 0.83 inch; height, 0.59 inch; convexity, 0.30 to 0.33 inch.

This shell has been referred by me with some doubt to *Anodontopsis* of McCoy, because it does not seem to correspond exactly in its hinge characters to his description of that genus, if I have correctly understood him. As the hinge of *Anodontopsis*, however, has not yet been illustrated, and it is generally difficult to form very exact conclusions in regard to the characters of the hinges of bivalves from a description only, the species is still retained here doubtfully in Prof. McCoy's genus. In first describing it, I proposed, in case that it should be found to be distinct, to designate the genus by the name *Orthodontiscus*, which may, in that case, be retained for it.

Prof. McCoy's description of the hinge of *Anodontopsis* reads as follows: "Hinge line shorter than the shell, with a posterior, long, slender tooth or cartilage plate extending just below it (double in the right valve), and another similar but shorter one in front of the beaks," and then adds that there is "occasionally one small cardinal tooth beneath the beak."

In the shell here described, the hinge may be characterized as having one rather well-defined, sub-trigonal, or somewhat obliquely extended, cardinal tooth under the beak of the right valve, and a corresponding pit under the beak of the left valve, with sometimes an appearance of a small rudimentary tooth just in advance of this pit. Of posterior lateral teeth, there is, in the right valve, a long one ranging parallel to the cardinal margin, with a parallel furrow above and below it for the reception of

two long posterior laterals in the left valve, the lower one of which is more prominent, and the upper merely linear or rudimentary. The furrow between these two posterior lateral teeth of the left valve is well defined, and receives the corresponding tooth of the other valve. Below the lower of these furrows, on the posterior side of the right valve, there is a very slight marginal ridge, that possibly may sometimes assume the character of a second posterior lateral tooth; but it is most prominent anteriorly, where it connects with the cardinal tooth, of which it seems rather to be an oblique posterior prolongation, than a distinct tooth.* On the anterior side, there is one shorter, anterior lateral tooth in the right valve, also ranging parallel to the hinge margin, and above and below this a little furrow for the reception of two small anterior laterals in the left valve, which receive between them that of the right valve.

The pallial line is certainly simple, and the muscular impressions well defined, the posterior one being larger than the other, and provided with a small accessory scar above, just under the posterior ends of the posterior lateral teeth. The ligament or cartilage was probably small and internal, as there are no traces of an external ligament to be seen, the valves fitting closely all along the hinge margin. No lunule or eschutcheon is to be seen in any of the specimens.

It is of course generally very difficult to determine, with certainty, the family affinities of such fossil shells, but I am inclined to regard this type as more probably belonging to the *Crassatellidæ*, than to the *Mytilidæ*, with which Prof. McCoy associates *Anodontopsis*.

The species here described was named in honor of S. A. Miller, Esq., of Cincinnati, who sent to the Smithsonian Institution the first specimens of it I have seen. I am also indebted to him for some broken valves showing the hinge. For the use of a specimen with the hinge of the left valve exposed, I am likewise under obligations to C. B. Dyer, Esq., of Cincinnati.

Locality and position: Forty miles west of Cincinnati, Ohio, from above the middle of the Cincinnati group of the Lower Silurian.

Anodontopsis (Modiolopsis?) unionoides, Meek.

Plate 12, figs. 2 *a*, *b*.

Anodontopsis? unionoides, 1871; Am. Jour. Sci. and Arts, Vol. II., p. 299 (issued Sept. 29th, for Oct., 1871).

Shell thin, sub-ovate, rather compressed, most convex slightly above and in advance of the middle; anterior margin regularly rounded; basal

* Unfortunately, figure 1 *d* does not give a very correct idea of some of the details of the hinge of the right valve.

margin forming a broad semi-elliptic curve, or nearly straight along the middle; posterior margin sloping from the posterior extremity of the hinge above, and rounded into the base below; hinge line straight apparently rather short; beaks depressed nearly to the hinge margin, small, and placed between one-fourth and one-fifth the length of the valves from the anterior end. Surface showing only a few distant sub-imbricating marks of growth.

Length, 1.75 inches; height, 1.14 inches; convexity, 0.63 inch.

Having no very satisfactory knowledge of the hinge of this shell, I am in considerable doubt regarding its generic characters. Mr. Miller sent me a right valve *apparently* belonging to it, that shows the interior and something of the hinge. It has been worn or macerated, however, so as nearly to obliterate the hinge characters. It, nevertheless, shows some appearance of a pit nearly under the beak for the reception of a cardinal tooth in the other valve; and just in front of the pit, the margin shows a slight prominence that may be the remains of a cardinal tooth. I cannot see any satisfactory evidence, however, that it had either anterior or posterior lateral teeth. Its anterior muscular impression is moderately distinct, without being very deep. Its outline is ovate, and it is placed quite near the anterior margin. The posterior muscular impression is not seen in the specimen, but was evidently very faintly defined.

This valve is a little shorter, and proportionally higher, than the typical form of the species under consideration, and may or may not belong to the same. As far as it gives any indications of the nature of the hinge, it would seem not to agree with that of *Anodontopsis* or *Modiolopsis*, but we yet want positive information on this point.

Locality and position: Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian, at the horizon of 340 feet above the Ohio river.

In first publishing a notice of this species, owing to a misunderstanding, I erroneously gave 40 miles below Cincinnati as the locality at which it was found. Mr. Miller has since informed me that he found the typical specimens, as stated above, at Cincinnati.

Genus SEDGWICKIA, McCoy, 1844.

(Synop. Carb. Fossils of Ireland, p. 61.)

Sedgwickia (?Grammysia) neglecta, Meek.

Plate 12, fig. 8.

Sedgwickia (Grammysia?) neglecta, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 325.

Shell transversely ovate, about one-third longer than high, rather distinctly compressed, most convex, and most elevated, in the central and

umbonal regions, and compressed-cuneate behind; anterior margin rounding from the lower end of the lunule into the base, which forms a nearly semi-oval curve, its most prominent part being near the middle; cardinal margin apparently straight and declining posteriorly from the beaks; posterior margin rather narrowly rounded; beaks moderately prominent, and scarcely one-third the length of the valves from the anterior margin. Surface ornamented with regular, distinct, but not very prominent concentric costæ, that become suddenly obsolete on the posterior third of the valves. Lunule narrow, but sharply defined.

Length, about 1.04 inches; height, 0.67 inch; convexity, about 0.35 inch.

The only specimen of this species I have seen, is an external cast of the right valve, that has evidently been, to some extent, accidentally compressed in the region of the beak, but the shell was certainly never very convex. It has almost exactly the general aspect, and kind of ornamentation, seen in the typical forms of *Sedgwickia*, a group that has been, since it was first proposed by Prof. McCoy, included by him in his genus *Leptodomus*, which seems to me to have been originally founded on a very distinct type.

Our shell also resembles, rather closely, some forms apparently falling into the genus *Grammysia;* that is, some of the species that present the aspect of that genus, excepting that they want the characteristic oblique ridge of the typical species. Until other specimens can be examined, and more is known in regard to the hinges of *Grammysia* and *Sedgwickia*, as well as that of the shell under consideration, its generic relations cannot be satisfactorily determined.

Locality and position: Upper part of the Cincinnati group of the Lower Silurian, Clinton county, Ohio. Mr. James's collection.

Sedgwickia? fragilis, Meek.

Plate 12, figs. 3 *a*, *b*.

Sedgwickia? fragilis, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 323.

Shell rather small, apparently very thin, longitudinally oblong, or sub-oval, rather distinctly convex along the umbonal slopes, from the beaks toward the posterior basal margin, and down near the anterior side; while just under the beaks, a rather strongly marked impression descends, widening and deepening as it approaches the base; basal margin sub-parallel in its general outline to the dorsal, but diverging more

or less posteriorly, where it is most prominent, while it is rather distinctly sinuous toward the front; posterior margin wider than the anterior, and more or less truncated; anterior extremity very short, and rounded or somewhat truncated; hinge line straight and shorter than the entire length of the valves, apparently very slightly inflected behind the beaks, which are raised a little above the cardinal margin, incurved, contiguous, flattened on the outer sides, and placed near the anterior end, with a slight, forward inclination. Surface ornamented with moderately distinct lines and irregular minute wrinkles of growth.

The only specimens of this species yet known to me, are too imperfect to afford exact measurements, though they seem to have been, when entire and undistorted, about 0.90 inch in length, 0.73 inch in height, and 0.40 inch in convexity. They present some appearance of having been gaping behind, and in the anterior ventral region. One specimen looks as if it had been truncated, with a backward obliquity, from below upward, behind, but this may be due to distortion.

I am far from being satisfied that this shell is congeneric with the forms for which Prof. McCoy proposed the name *Sedgwickia*, as nothing can be determined, from the specimens yet known, in regard to its hinge and muscular and pallial impressions. Possibly I would be nearer right to call it *Modiolopsis fragilis*, but there is something in its physiognomy that suggests affinities to Carboniferous types referred to *Sedgwickia* and *Allorisma*.

Locality and position: Cincinnati group of the Lower Silurian, at about 350 feet above low-water mark of the Ohio river, at Cincinnati, Ohio. Mr. U. P. James's collection.

Sedgwickia? compressa, Meek.

Plate 12, figs. 7 *a*, *b*.

Anatina sinuata, James, 1871; Catalogue Fossils, Cincinnati Group, p. 12 (not *Anatina? sinuata*, Hall).

Sedgwickia? compressa, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 324.

Shell longitudinally oval, compressed, about one-fourth longer than high, cuneate posteriorly, and more convex in the central and anterior regions, with a slight concavity descending from the beak to the base of each valve; posterior margin regularly rounded; base straight and parallel to the cardinal margin in the middle, and rounding up to the anterior and posterior margins; anterior side short, rounded, or somewhat

truncated, but apparently most prominent below; hinge line shorter than the valves, straight behind the beaks, but rounding into the posterior margin at the extremity, erect behind, with some appearance of a narrow space for an external ligament farther forward; beaks about one-fourth the length of the valves from the anterior margin, raised a little above the cardinal margin, nearly contiguous, but not much incurved. Surface of a cast that seems to be a little weathered or smoothed by attrition, showing obscure marks of growth.

Length, 0.77 inch; height, 0.59 inch; convexity, 0.29 inch.

I have only seen a single specimen of this species, and as it is a mere cast, not showing clearly even the surface markings, little can be said in regard to its affinities. I am even left in some doubt whether its shorter side may not be the posterior instead of the anterior, as there is some appearance about the points of the beaks of their being rather directed toward the longer than toward the shorter side. The appearance, however, of a narrow space along the cardinal margin on the longer side, as if for an external ligament, seems to indicate that this is the posterior. The margins of the valves on the anterior? (shorter) side are a little defective above in the specimen, so as to leave room for some doubts whether it was regularly rounded in outline or not.

Although the specimens of the last described species are much distorted, it is evident, I think, that they are quite distinct from this, as it would seem impossible to make this shell assume the shape and convexity of the last by any conceivable degree of distortion.

Mr. James referred this species, in his list, to the Upper Silurian fossil *Anatina? sinuata*, Hall, which it resembles in form. Still it seems to me to differ too much in its more elevated beaks, shorter anterior, and straighter basal outline, to be referred to that species, even if found in rocks of the same age; while the rather wide interval between the horizons at which the two forms occur, renders it still more improbable that they belong to the same species.

It is extremely difficult to arrive at correct conclusions in regard to the generic affinities of such shells from the study of mere casts, and it is therefore only provisionally that I have referred this and the last described species to the genus *Sedgwickia*. We may rest quite well assured, however, that palæozoic forms of the kind cannot be properly referred to the existing genus *Anatina*.

Locality and position: Same as last. Mr. James's collection.

Genus CARDIOMORPHA, de Koninck, 1844.

(Anim. Foss. Carb., Belg., p. 101.)

Cardiomorpha?? obliquata, Meek.

Plate 12, figs. 4 *a*, *b*.

Cardiomorpha?? obliquata, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 327.

Shell small, rhombic-cordate; very convex, higher than long; posterior margin sloping rather abruptly, and sub-truncate, or a little convex in outline from the posterior extremity of the hinge to the posterior basal extremity, which is more or less angular or narrowly rounded; basal margin short, nearly straight or a little convex from the posterior basal extremity to the front; anterior margin short or truncated from immediately in front of the beaks obliquely downward and backward to the base, which it joins at an obtuse, slightly rounded angle; hinge line very short, ranging at an angle of about fifty degrees to the umbonal axis, and apparently having its margins a little inflected behind the beaks; beaks very prominent, oblique, nearly or quite terminal, and strongly incurved; posterior umbonal slopes sub-angular near the points of the beaks, but becoming rounded below, while the dorsal region between this and the hinge is a little concave; anterior umbonal slopes forming a kind of ridge, that extends, at something less than a right angle to the hinge, to the anterior basal margin, the anterior side thus circumscribed being somewhat flattened, and, as seen from the front, presenting a cordate outline. Surface ornamented with small, very regular, simple concentric costæ, that seem to be obsolete on the anterior and posterior portions of the valves. Hinge and interior unknown.

Length parallel to the cardinal margin, about 0.45 inch; height at right angles to hinge, to the tops of the beaks, about 0.45 inch; length, measuring from the points of the beaks obliquely to the posterior basal extremity, 0.57 inch; convexity, 0.39 inch.

I have referred this shell provisionally to *Cardiomorpha*, rather because it seems to present at least as many external points of resemblance to some species of that genus as to any known palæozoic group, than from any strong impression that it really is a true *Cardiomorpha*. In some respects, its general physiognomy suggests affinities to the group of secondary shells for which Prof. Agassiz proposed the name *Ceromya*, though I do not think it would fall into that genus. When all of its characters can be determined, it will probably be found to belong to an

undescribed genus. If so, I would propose for the group *Ceromycopsis*, from its resemblance to some species of *Ceromya*.

Although presenting some points of resemblance to the last described species, this shell may be distinguished at a glance, not only by its small, distinct concentric costæ, but by its much less sharply carinated beaks, and more rounded posterior umbonal slopes, as well as by its flattened anterior side, which flattening imparts a sub-angular character to its anterior umbonal slopes, not seen in the last.

Locality and position: Cincinnati group of the Lower Silurian, at Cincinnati, Ohio. Mr. Dyer's collection.

GASTEROPODA.

Genus CYRTOLITES, Conrad, 1838.

(Ann. Rept. Palæont. N. Y., p. 118.)

Cyrtolites (Microceras*) inornatus, Hall (sp.).

Plate 13, figs. 4 *a*, *b*.

Microceras inornatus, Hall, 1845; Am. J. Sci. and Arts, Vol. XLVIII., p. 294.

Shell very small, sub-discoid; volutions apparently about two, increasing rapidly in size, slightly embracing, most convex near the umbilicus (into which the sides round abruptly), and sub-carinate around the periphery; umbilicus scarcely as wide as the dorso-ventral diameter of the outer volution at the aperture, and rather deep; aperture subcordate, approaching sub-triangular; surface smooth.

Greatest diameter, 0.07 inch; convexity, 0.04 inch.

There are two varieties, or possibly species, of these little shells, the only differences between which seem to be, that one is rather decidedly more compressed than that I have described above; and, as Prof. Hall gave no measurement of the convexity of his type (which has never been figured), I am left in some doubt which form it was that he named. As he described the aperture, however, of his species as being "somewhat quadrangular," which would be very inapplicable to that of the more compressed form, I infer that it was the convex one he named. Should it be thought desirable to designate the more compressed form by another name, it may be called *C. subcompressus*.

Prof. Hall thought these little shells probably septate, and proposed

* Not *Microceras*, Hyatt, 1868.

to found a new genus, *Microceras*, for them. As I have been unable to see any indications, however, of septa, either in broken specimens, or in a ground section of one, made parallel to the plane of its greater diameter, I cannot believe they are septate; and their form being exactly that of *Cyrtolites*, I know of no other reasons than their small size, smooth surface, and perhaps their less acutely angular dorsal margin, for separating them from that genus. Their small size, however, would be a still stronger objection to the conclusion that they are Cephalopods, even if we know them to be chambered shells, because we have no example of so small a form in that class; while some Gasteropods, and, I believe, Pteropods also, are known to secrete partitions across the shell behind the animal, as it increased in size, and, at intervals, withdraw itself from the smaller part of the shell. For these reasons, it seems to me that we are more apt to be right in referring these shells to *Cyrtolites*, than by viewing them as typical of a distinct genus, either of Gasteropods or Cephalopods.

Locality and position: Cincinnati group, top of hills, at Cincinnati, Ohio. Specimens received from Mr. James, Mr. Miller, and Mr. Dyer, of Cincinnati.

Cyrtolites ornatus, Conrad.

Plate 13, figs. 3 *a*, *b*.

Cyrtolites ornatus, Conrad, 1838; Ann. Geol. Report, N. Y., p. 118; *ib.* (1839), p. 63, and *ib.* (1841), p. 37; Vanuxem (1842), Geol. Report, p. 65, fig. 2; Emmons (1842), p. 402, fig. 2; Hall (1847), Palæont. N. Y., Vol. I, p. 308, pl. LXXXIV., figs. 1 *a-g*.

Shell attaining a rather large size; volutions two to three, rapidly increasing in size, very strongly and sharply carinate around the dorsal margin, and the outer one with a sharp furrow on its ventral side for the reception of the dorsal keel of the inner turns; in internal casts, all the whorls appearing rather widely separated; sides of volutions prominent or sub-angular around somewhat within the middle; umbilicus wide and deep; aperture rhombic subquadrate. Suface ornamented by strong, distant sub-angular ridges, and deep, rounded, wider furrows between; both ridges and furrows extending obliquely outward and backward from the most prominent part of the sides of the volutions, to or toward the dorsal carina; covering the whole, there are also numerous very fine, regular, transverse striæ, and crossing between these, numerous little, short, alternately arranged, raised lines, thus forming a very delicate reticulate style of sculpturing, somewhat resembling the pitting of a thimble.

Greatest diameter of an adult specimen, 1.05 inches; convexity at the aperture (which is also the breadth of the same), 0.60 inch; dorso-ventral diameter of aperture, 0.56 inch.

Locality and position: In New York this species occurs at many localities, and ranges from the Trenton limestone into the equivalent of the Cincinnati group. It also occurs in Canada. The specimen here figured is from the latter group at Cincinnati, and belongs to Mr. Dyer's collection.

Cyrtolites Dyeri, Hall.

Plate 13, figs. 2 *a*, *b*, *c*, *d*, *e*.

Cyrtolites Dyeri, Hall; Advance sheets Regents' 24th State Cab. Report, dated Oct., 1871; and reissue of same (1872), pl. 4, figs. 7 and 8.

Shell discoid, with convexity about two-fifths the greatest breadth; periphery carinated; sides moderately convex, rounding more abruptly into the umbilicus than to the periphery; volutions apparently three or four, increasing rather gradually in size, slightly wider than their dorso-ventral diameter, and more or less embracing; umbilicus about equaling the dorso-ventral diameter of the last turn at the aperture, which is cordate in form. Surface ornamented by about ten small revolving ridges on each side, and numerous very closely crowded, regularly undulating, raised transverse lines, that make a short forward curve between each two of the revolving ridges.

Convexity, 0.29 inch; greatest diameter, 0.45 inch; breadth of umbilicus, about 0.15 inch; spaces between the revolving ridges at the aperture, 0.03 inch; number of transverse undulating lines in same space near aperture, three or four.

The beautifully ornate species seems to be most nearly related to *C. compressus* of Conrad, but may be readily distinguished by its regular, continuous revolving ridges, and densely crowded transverse undulating, raised lines; which latter are greatly more distantly separated in Mr. Conrad's species. It is also a smaller shell, with more embracing volutions.

One specimen in Mr. Dyer's collection from the Cincinnati rocks, only shows about five of the revolving ridges on each side, and these are very obscure. Its dorsal keel has a marginal line on each side, and shows the raised marks of growth crossing the very narrow space between these to be distinctly curved backward, like those usually seen on the band of *Pleurotomaria*. In some respects, this form resembles *C. compressus*, Con-

rad, but it differs materially in having the undulating lamellæ of growth *much* more crowded, and in the presence of obscure revolving lines. It seems to me to be only a variety of the above described species.

Locality and position: Cincinnati group, at Cincinnati, Ohio. Mr. Dyer's collection.

Cyrtolites ? costatus, James.

Plate 13, figs. 1 *a*, *b*, *c*.

Cyrtolites costatus, James, 1872; Am. Jour. Sci. and Arts, Vol. III., 3d series, p. 26.

Shell thin, composed of two and a half to three rapidly enlarging, rounded volutions, the inner of which are contiguous, or possibly very slightly embracing, while the last half-turn becomes a little disconnected from the others; umbilicus rather large and deep; dorsum rounded, and without any traces of a keel; aperture unknown, but section of volutions nearly or quite circular. Surface ornamented by distinct, raised revolving lines or costæ, which increase in number by the intercalation of smaller ones between the others, as the shell increased in size, so as to present an alternately larger and smaller series, or at some stages of growth, showing three smaller between each two of the largest, in which case the middle one of the smaller three is usually a little larger than the other two; crossing the whole, thin, raised laminæ of growth generally occur at irregular distances, and between these, numerous minute, crowded transverse striæ may be seen, by the aid of a magnifier.

Greatest diameter, about 0.84 inch; convexity of the body volution, about 0.54 inch.

This seems to me not to be a true *Cyrtolites*, or at least to belong to a very distinct section of the genus from the typical species. on account of having no traces of the dorsal keel so strongly defined on the other species included in the group. It agrees, however, with *Cyrtolites*, and differs from *Bellerophon* and *Bucania* in its habit of growth, particularly in having its body volution partly disconnected from the others. It doubtless also differs from the latter two groups—more particularly the latter—in not having its lip expanded.

Its larger size, rounded dorsum, without a keel, and stronger revolving lines, will at once distinguish it from the last, from which it also differs in wanting the regular, waved, tranverse marks of growth of that shell.

Locality and position: About the middle of the Cincinnati group of the Lower Silurian, in Warren county, Ohio. Mr. James's collection. I am also under obligations to Mr. Klippart, of Columbus, for the use of a specimen of this species.

Genus CYCLONEMA, Hall, 1852.

(Palæont. N. Y., Vol. II., p. 89.)

Cyclonema bilix, Conrad (sp.).

Plate 13, figs. 5 *a, c, d, g;* and 5 *e, f?*

Pleurotomaria bilix, Conrad, 1842; Jour. Acad. Nat. Sci., Vol. VIII., p. 271, pl. 16, fig. 10.

Pleurotomaria (?) *bilix*, Hall, 1847; Palæont. N. Y., Vol. I., p. 305, pl. LXXXIII., figs. 4 *a, b, c, d, e.*

Cyclonema bilix, Hall, 1852; 12th Report Regents (1859), p. 74.

Shell varying from rhombic sub-globose to conoid-sub-trochiform; spire conical, but very variable in its elevation, thus causing considerable variation in the relative length and breadth of the entire shell, which, however, is most generally somewhat longer than the breadth; volutions four to five, increasing rather rapidly in size, compressed-convex, the compression being very variable in degree, and usually parallel to the general slope of the sides of the spire; last, or body turn, more or less narrowly rounded, or sometimes almost sub-angular below the middle; suture varying from merely linear to rather deeply channeled; aperture broad ovoid to subquadrate; inner lip thickened, a little straightened and rather distinctly flattened, from near the middle downward; outer lip sharp and very oblique. Surface ornamented by revolving lines and furrows, that vary greatly in size, arrangement and distinctness, and are crossed by fine, very oblique, regular, thread-like lines, and sometimes irregular ridges of growth; both of which, however, are subject, occasionally, to become nearly or quite obsolete.

Height of a medium-sized specimen of typical form, 0.84 inch; breadth, 0.82 inch.

This is an exceedingly variable shell, so much so, indeed, that it is difficult, even after excluding some extreme forms that may be distinct species, to assign it definite characters. These variations consist not only of differences of general form, but also in the depth of the suture, the convexity of the volutions, and the outline of the aperture, as well as in the nature of the surface markings. The fine, regular, very oblique lines of growth, are most constant, but the revolving lines, ridges and furrows, are very variable in size and arrangement. All of these different varieties of form and surface markings, however, shade into each other by intermediate gradations, to such an extent that it seems hardly possible to separate them more than as varieties. Prof. Hall has sepa-

rated one of the extreme forms, under the name *C. varicosa*. (See Regents' 14th State Cab. Report, p. 91; and pl. 4, figs. 1 and 2, issued with a paper extracted from Regents' 24th Report.) This form has remarkably strong and irregular revolving ridges and furrows, as well as an unusual straightness of the columella. It is probably a distinct species; but I have seen such a series of gradations in these characters, as to lead me to suspect that it *may* be only an extreme variety.

Another form going to the opposite extreme, now before me, is so much depressed as to be decidedly wider than high, and has, along with the usual fine regular revolving lines, and minute oblique striæ of growth, strong oblique rounded ridges, interrupted by a broad shallow depression around the middle of the upper slope of the body volution. For this form (represented by our figures 5 *e, f*, of plate 13) I would propose the name *C. bilix var. lata*. It seems to me to be as strongly separated from the typical *C. bilix*, as that named *C. varicosa* by Prof. Hall (though in a different way), as may be seen by our figure 5 *a*, of plate 13, drawn from the typical variety.

Our figs. 5 *c*, *d*, of the same plate, represents another form coming very near *C. Hageri*, Billings. There are also among the collections now before me, others that have a decidedly more elevated spire, and a more narrow conical general form than any of those figured; and still others with the spire *much* depressed, and the body volution comparatively large, rounded and ventricose, with a deep suture. In short, it would require almost an entire plate to illustrate all the varieties of this protean group of varieties or species.

Locality and position: Mr. Conrad's typical specimens of this shell were from Richmond, Indiana, where they occur in the upper part of the Cincinnati group. Those here figured are all from Cincinnati, where they range through several hundred feet of the same group, at lower horizons. It also occurs near the top of the group, at Madison, Indiana. It is likewise found at numerous places in this group, in Kentucky, Wisconsin, Iowa, etc.

Genus CYCLORA, Hall, 1845.

(Am. Jour. Sci. and Arts, Vol. XLVIII., p. 294.)

Cyclora minuta, Hall.

Plate 13, figs. 7 *a, b, c, d, e.*

Cyclora minuta, Hall, 1845; Am. Jour. Sci. and Arts, Vol. XLVIII., p. 294.

Holopea (*Cyclora*) *nana*, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., Aug., 1871, p. 172.

Shell very small, sub-globose, wider than high; spire much depressed; volutions three, rounded, increasing rather rapidly in size, so that the

last one forms the larger bulk of the shell; suture deep, or almost channeled; surface smooth; umbilicus small; aperture circular; lip thin.

Height of largest specimen seen, 0.05 inch; breadth, 0.07 inch.

At the time I described this little shell under the specific name *nana*, I had no specimens known to be authentic examples of Prof. Hall's *Cyclora minuta* from Cincinnati at hand for comparison, though I was aware, and so stated in my remarks, that it must be closely related to his type, as appeared evident from his description. Being under the impression, however (owing to the almost illegible condition of the label), that the specimens studied by me had been found in the equivalent of either the Clinton or Niagara group, and knowing how improbable it must be for the same species of such a shell to occur both in the Cincinnati group and at either of these higher horizons, I confidently believed there must be some specific differences between the specimens I had under consideration and those found at Cincinnati.

After the publication of my paper, specimens of *Cyclora minuta* were sent on from the original locality at Cincinnati, along with others of different kinds, by several gentlemen; and a critical comparison of these with those I had described, and of both with the description of *Cyclora minuta*, soon led me to the conclusion that they are almost certainly the same species. On inquiry, I have also been informed that the specimens described by me, under the name *nana*, must have been found in the Cincinnati group, as none of the gentlemen connected with the Survey remember having collected any such specimens from any higher horizon. This being the case, I have placed my name, *nana*, as a synonym under *C. minuta*, though figures of the type specimens are also given on the same plate, by the side of others certainly known to have been found at the original locality from which *C. minuta* was first obtained.

In regard to the genus *Cyclora*, not much can be said. It seems to differ from *Holopea*, mainly in size; but the difference of size alone is so great as to favor the conclusion that these little shells belong to a distinct genus, probably belonging to the *Rissoidæ*.

Locality and position: Cincinnati group, Cincinnati, Ohio, where it is found associated with other very small shells of several genera, near the tops of the hills. I have also received specimens of apparently the same shell from several lower positions at and near Cincinnati; and Prof. Orton thinks it ranges through nearly the whole thickness of the Cincinnati group. Specimens were received from Mr. James, Mr. Miller, and other persons at Cincinnati.

Cyclora? parvula, Hall, (sp.).

Turbo? parvulus, Hall, 1845; Am. Jour. Sci. and Arts, Vol. XLVIII., p. 294.

Shell very small, conoid-sub-ovate; spire conical; volutions three or four, increasing moderately in size, strongly convex, the upper ones being nearly round, and the lower obtusely angular around the middle; suture very deep in consequence of the convexity of the whorls; aperture nearly circular; umbilical perforation very small; surface smooth.

Length, 0.05 inch; breadth, scarcely 0.04 inch.

This little shell will be at once distinguished from the last by its more elevated spire, and obtusely sub-angular lower volutions. It may, and probably does, belong to a different genus from the last, but we may feel well assured that it does not belong to the genus *Turbo*, nor even to the same family.

Locality and position: Found associated with the last, near the tops of the hills, at Cincinnati, Ohio, in the Cincinnati group of the Lower Silurian. I have also seen specimens of the same, or a very similar form, from not more than twenty feet above low-water mark of the Ohio, at Cincinnati, associated with a form very like the last. The specimens from this horizon, however, were imbedded in the matrix, so that a very critical comparison could not be made.

Genus PLEUROTOMARIA, Defrance, 1826.

(Dict. Sci. Nat., p. 381, Vol. XLI.)

Pleurotomaria (Scalites?) tropidophora, Meek.

Plate 13, figs. 6 *a*, *b*, *c*.

Pleurotomaria (*? Scalites*) *tropidophora*, Meek, 1872; Am. Jour. Sci. and Arts, Vol. IV. (3d series), p. 278.

Shell rather small, obliquely rhombic in general outline, as seen in a side view; height somewhat greater than the breadth; spire conical, with an apical angle of about 70° to 90°;* volutions four to four and a half, each flattened, or sometimes slightly concave above, with an outward slope from the suture to a prominent angle that passes around the middle of the body turn, and below the middle of those of the spire, to

* The larger specimens have the spire proportionally more elevated.

which it imparts a somewhat turreted appearance; suture moderately distinct, but not channeled; lower side of body volution sloping rapidly inward from the mesial angle, a little below which there usually revolves an obscure, undefined ridge; aperture rhombic subquadrate. Surface nearly smooth, but sometimes showing, under a magnifier, very obscure lines of growth, that curve very strongly backward as they approach the angle around the middle of the body volution, both above and below; thus indicating the presence of a deep sinus in the lip, widening rapidly forward, though there is no defined revolving band at the angle.

Length or height, 0.55 inch; breadth, about 0.50 inch.

This shell seems to possess some of the characters of both *Pleurotomaria* and *Scalites*. In general appearance, it is most like some forms of the former; but it seems to be entirely without the revolving band seen on the species of that genus. Its lines of growth, however, have the very strong, oblique backward curve seen in those of *Scalites*, thus showing that its lip, when entire, must have had a deep notch at the termination of the angle of the body whorl. This notch, however, does not appear to terminate in a sharply cut slit, as is most generally the case in *Pleurotomaria*, but seems to have terminated at, and widened rapidly forward from, the angle of the volutions.

Specifically, this shell is related to *Pleurotomaria selecta* of Billings, from which it differs in having its striæ of growth nearly obsolete, and in wanting the revolving angle just below the suture, seen in that species.

Locality and position: Cincinnati group, at Cincinnati, Ohio. Mr. Miller's collection.

CEPHALOPODA.

Genus ORTHOCERAS, Auct.

Orthoceras Ortoni, Meek.

Plate 13, fig. 8.

Orthoceras Ortoni, Meek, 1872; Proceed. Acad. Nat. Sci., Philad., p. 330.

Shell rather rapidly expanding from the posterior toward the aperture; section oval or more or less nearly circular; septa rather closely arranged; siphuncle lateral, being at one of the narrow ends of the compressed section, but not quite marginal, of comparatively moderate

size, and apparently beaded; surface of cast showing traces of regular, obscure longitudinal ridges, that were probably not defined on the exterior of the shell, which is unknown.

I have seen but two specimens of this species, and they are accidentally compressed and incomplete at both extremities. The more nearly complete one of these specimens is about 2.30 inches in length, and septate throughout, as may be seen by the figure. At the larger end, it measures about 1.37 inches in breadth, and only 0.44 inch in its smaller diameter; while at the smaller end, its greater diameter is 0.38 inch, and its smaller 0.24 inch. It has manifestly, however, been accidentally compressed, more strongly at the larger end, which gives the appearance of more rapid expansion toward the aperture than the natural form. The septa near the larger end are separated by spaces measuring 0.15 inch, and at the smaller end measuring 0.07 inch. At the larger end, the very obscure longitudinal ridges measure each about 0.05 inch in breadth, with furrows of the same breadth between, and both diminish proportionally in size, and become nearly obsolete toward the smaller end.*

This species apparently belongs to the section of the genus consisting of rather rapidly expanding shells, with a nearly marginal siphuncle, sometimes showing faint longitudinal ridges on the internal cast, that are not defined on the external surface, such, for instance, as *O. compulsum*, *O. robustum*, *O. indocile*, etc., etc., of Barrande. It resembles several of Barrande's Bohemian species of this type, but after repeated comparisons, I have been unable to identify it with any of the numerous species described by him; and it seems to be equally distinct from all of those described in this country and Canada.

The only specimens of this shell I have seen, are so imperfect and flattened by accidental pressure, as to leave some doubts whether it may not have been, in its perfect condition, slightly curved. If so, it will have to take the name *Cyrtoceras Ortoni*, as it could not, in that case, be properly retained in the genus *Orthoceras*.

The specific name is given in honor of Prof. Edward Orton, of the Ohio Geological Survey.

Locality and position: Cincinnati group, at Cincinnati, Ohio. Mr. Dyer's collection.

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* The figure of this species, given on pl. 13, is defective, in making the merely white edges of the septa, as seen in the cast of the interior, look like prominent transverse ridges.

Genus TROCHOCERAS, Barrande, 1847.*

(Haid. Mith. Wien. Natf. Fr. III., p. 266.)

Trochoceras? Baeri, M. and W.

Plate 13, fig. 9.

Trochoceras? Baeri, Meek and Worthen, 1865; Proceed. Acad. Nat. Sci., Philad., Dec., 1865, p. 263.

Shell sub-discoidal, consisting of about two or three rather rapidly enlarging volutions, which are more broadly rounded on the outer surface than on each side, and about one-fourth wider transversely than the dorso-ventral diameter; each inner volution slightly impressing the inner side of the succeeding turn. Umbilicus a little more than half the dorso-ventral diameter of the outer volution, and showing all the inner turns. Spire apparently scarcely (or perhaps not) rising above the upper surface of the last turn. Septa rather distinctly concave on the side facing the aperture; separated on the outer side of the whorls (at a point where the dorso-lateral diameter is about 1.25 inches) by spaces measuring 0.35 inch; all showing a very slight backward curve on the broadly rounded periphery, and passing nearly straight across each side. Surface, siphuncle, and non-septate part of the shell not certainly known.

Greatest breadth of the typical specimen (which is septate) to the broken outer extremity, 5 inches; height, or thickness of same, about 2.50 inches. Dorso-ventral diameter of the volutions increasing about three-fold each turn.

The specimen from which this description was drawn up, is defective on one side, so that it is not easy to determine whether or not its whorls are coiled exactly in the same plane, though they have the appearance of being somewhat oblique, and hence it was placed provisionally in the genus *Trochoceras*. Should it be found, however, when better specimens can be examined, that its whorls are coiled all in the same place, it would belong either to the genus *Lituites*, or to some section of the genus *Nautilus*, as the latter group is understood in its less restricted sense, and of course have to take the name *Lituites Baeri* or *Nautilus Baeri*.†

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* Prof. Hall proposed this name for this same genus, during the same year, but I do not know which issued the description first.

† As the outer volution shows some tendency to become free at the point where it is broken, this would favor the conclusion that it may be a Lituite.

The typical specimen does not show the position of the siphuncle, but fragments from the same locality and position, apparently belonging to this shell, have the siphuncle located rather more than its own breadth outside of the center; and it pierces the septa from without inward, or backward, as in *Nautilus*.

At a first glance, this shell reminds one of *Lituites undatus*, as represented in the Palæontology of New York, Vol. I., pl. 13, fig. 3, but on a closer examination, it will be at once seen to differ materially in the more rapid increase in the breadth of its whorls, and in the proportionally smaller size, and greater depth of its umbilicus, as well as in being apparently not coiled on a plane.

The specific name was given in honor of Dr. O. P. Baer, of Richmond, Indiana, to whom I am under obligations for the use of the typical specimen.

Locality and position: Upper beds of the Cincinnati group, at Richmond, Indiana, and in Warren and Clinton counties, Ohio.

ARTICULATA.

CRUSTACEA.

ENTOMOSTRACA.

Genus CYTHERE, Muller, 1785.

Cythere Cincinnatiensis, Meek.

Plate 14, figs. 1 *a*, *b*, *c*, *d*.

Cythere Cincinnatiensis, Meek, 1872; Proceed. Acad. Nat. Sci., p. 331.

Carapace-valves varying from transversely sub-oval to sub-circular; moderately and rather evenly convex, the greatest convexity being in the central and anterior regions; without any visible eye-tubercle or node; ventral margins rounded or semi-oval, and but slightly unequal or thickened; anterior and posterior margins more or less rounded, the former being more broadly rounded generally than the latter; hinge margin very short, very slightly sinuous just behind the umbones, and rounding into the posterior margin so as scarcely to produce any visible angularity; umbones, near the anterior, a little tumid, rising very slightly above the hinge, and rounding off regularly into the anterior margin. Surface nearly smooth.

Length of one of the larger, nearly circular specimens, 0.21 inch; height, 0.17 inch; convexity, 0.11 inch. Length of a smaller, more oval specimen, 0.14 inch; height, 0.08 inch; convexity, 0.07 inch.

This species seems to vary a good deal in form, some specimens being, as the above measurements indicate, proportionally higher, and thus presenting a more rounded outline. It is possible that these forms may belong to two distinct species, but with the specimens yet accessible for study, I have not felt warranted in separating them.

Locality and position: Cincinnati group, at Cincinnati, Ohio. Mr. Dyer's collection.

Genus ASAPHUS, Brougniart, 1822.

(Crust. Foss., p. 17.)

Asaphus (Isotelus) megistos, Locke?

Plate 14, fig. 13.

Isotelus megistos, Locke, 1842; Am. Jour. Sci. and Arts, Vol. XLII., p. 366; and (1843) in Reports of 1st, 2d and 3d meetings of Association Am. Geologists and Naturalists, p. 221, pl. VI.

Entire outline subelliptic, the breadth being nearly two-thirds the length, in a specimen apparently a little contracted by the drawing together of the thoracic segments, rather depressed convex; extremities elliptically and subequally rounded.

Cephalic shield forming about one-third the entire length, exclusive of the posterior lateral spines, nearly semi-circular, the anterior margin being rounded, and the posterior broadly and moderately sinuous, with the posterior lateral angles produced backward in the form of mucronate spines, that nearly or quite equal the length of the thorax. Lateral borders each provided with more or less defined marginal furrows, that extend from the anterior ends of the lateral spines forward, becoming very narrow or obsolete around the anterior end of the glabella. Glabella not rising above the general convexity of the cephalic shield, and but very faintly defined; anterior lobe or division transversely subelliptic, being nearly twice as wide as its anterio-posterior diameter back to the eyes, at which point the narrowest part, or neck of the glabella, is only about two-thirds as wide as its anterior lobe. Facial sutures extending forward and outward in advance of the eyes, then curving and converging to the middle of the front margin; posteriorly, extending at first obliquely outward and backward, and then curving backward so as to intersect the posterior margin at points less than half way out from the anterior ends of the furrows between the thoracic lobes. Neck furrow entirely obsolete. Eyes lunate, or forming about a semi-circle, of moderate size, and situated a little less than their direct length in advance of the posterior margin of the shield.

Thorax slightly less than the length of the cephalic shield, at its middle, composed of eight narrow segments. Lobes moderately well defined; mesial one depressed-convex, about one-fifth of its breadth wider than the lateral ones, and having its segments flattened; lateral lobes also depressed or flattened within, and rounding or sloping gently from near the middle to the lateral margins; pleuræ curving a little backward near the middle, furrowed for about half way out, rather obtuse at the ends, and each distinctly leveled along its anterior outer-half, so as readily to slip under the next one in advance of it, in rolling up.

Pygidium a little longer and slightly narrower than the cephalic shield, as well as rather more narrowly rounded at its middle, behind, with a more or less flattened margin; lobes and segments undefined, or only very obscurely visible.

Entire surface apparently smooth.

Length, 1.16 inches (may have been a little more when the thoracic segments were a little relaxed); length of pygidium, 0.38 inch; length of thorax, 0.40 inch; length of cephalic shield at its middle, 0.40 inch; length of its spines, each 0.33 inch.

If this form belongs to Dr. Locke's species, it must, of course, be a young individual, which might possibly account for its shorter, more nearly oval form. There are some other differences, however, that I am at a loss to account for, apparently distinguishing it from Dr. Locke's form, as restored by him, as well as from some of the characters given in his description; such, for instance, as the much greater proportional length of the posterior lateral spines of its head, which are very nearly as long as its thorax, instead of being only a little longer than the anterior two segments of the same. It also differs in having distinct marginal furrows along the cheeks, and a kind of flattened margin around the pygidium, as well as in having its pleuræ distinctly furrowed. There are also differences in the form of the glabella, particularly its anterior part, in front of the eyes.

As Dr. Locke's figure and description, however, were prepared from fragments only, and the species of this genus are known to be very variable, I prefer to refer this specimen provisionally to his species, rather than to undertake to separate it without other examples for study and comparison.

Locality and position: Cincinnati group, Cincinnati, Ohio.

Genus PROETUS, Steininger, 1831.

(Mem. Soc. Geol. France, Vol. I., p. 355.)

Proetus Spurlocki, Meek.

Plate 14, fig. 12.

Proetus Spurlocki, Meek, 1872; Am. Jour. Sci., Vol. III., 3d series, p. 426.

General form, exclusive of the spines of the cephalic shield, ovate subelliptic, with moderate convexity. Cephalic shield having the form of one of the halves of an ellipse divided through its shorter diameter, its posterior margin being straight, and its anterior narrowly rounded; posterior lateral angles produced into long, sharp spines, that extend back nearly or quite the entire length of the thorax; glabella nearly one-third the breadth of the posterior part of the head, separated from the cheeks on each side by a well-defined furrow, but without having the neck furrow distinctly marked; other details of glabella unknown. Eyes sublunate, nearly their own length in advance of the posterior margins of the cheeks.

Thorax apparently shorter than the head, showing (in the specimen examined) only seven segments (one or two being probably covered by the slipping backward of the cephalic shield). Mesial lobe moderately prominent, scarcely equaling the breadth of the lateral lobes anteriorly, and tapering more rapidly backward, with its segments not arching forward. Lateral lobes less convex than the middle one; pleuræ nearly straight and transverse, or very slightly curved backward, and furrowed for a little more than half way out with their extremities rounded in front, and nearly rectangular behind.

Pygidium sub-semicircular, about one-half as long as the cephalic shield, and provided with a smooth, flattened margin. Mesial lobe moderately prominent, narrower than the lateral, tapering posteriorly, where it terminates rather abruptly, without passing quite upon the flattened margin, showing only very obscure traces of five or six segments on its anterior half. Lateral lobes more depressed than the mesial one, and with their flattened margin rather more than one-third the breadth of the anterior end of each, and each showing obscure traces of six or seven furrowed segments.

Entire surface smooth.

Length of a specimen apparently slightly shortened by the slipping of the cephalic shield a little back upon the thorax, 0.33 inch; breadth at the widest point across the posterior part of the head, 0.25 inch; length of head, 0.27 inch; length of pygidium, 0.11 inch.

Until I saw the published figure of *Proetus parviusculus*, Hall, I had thought it possible that this might be the same, although it seemed not to agree in several characters with the description of that species previously published. On comparing it with the figure of that form, however, it will at once be seen to present well-marked differences. In the first place, its cephalic shield is decidedly longer in proportion to its breadth, and more narrowly rounded in front; while the posterior lateral spines of its cheeks are nearly or quite twice the proportional length of those in *P. parviusculus*. Its eyes are also placed decidedly farther forward, and its neck segment much less distinctly defined. When we come to its thorax, we also see equally well-marked differences, its pleuræ not being curved backward and falcate as in that species, nor having their furrows extending so far outward. It also almost certainly has one or two segments less, though the slight slipping backward of the cephalic shield leaves room for some little doubt on this point. I have, however, another, but inferior specimen before me, from the collection of Dr. H. H. Hill, of Cincinnati, believed to belong to this species, and this certainly has only eight thoracic segments. Again, the pygidium of our species differs in having a distinctly flattened smooth border, and very obscurely furrowed segments on the lateral lobes, that do not extend outward upon this border; while on that of *P. parviusculus*, the segments are strongly defined, without furrows, and extend very nearly or quite to the border, so as scarcely to leave any flattened margin.

The specific name of this trilobite was given in honor of T. W. Spurlock, Esq., of Cincinnati, who discovered some of the new fossils loaned to the Survey, and is well known in that city for his long devotion to the study of the natural sciences.

Locality and position: Cincinnati group of the Lower Silurian, at the horizon of about 100 feet below the tops of the hills at that city. Mr. Dyer's collection.

Genus CERAURUS, Green, 1833.

(Monogr. Trilobites, p. 83.)

Ceraurus icarus, Billings.

Plate 14, figs. 11 *a*, *b*, *c*.

Cheirurus icarus, Billings, 1859; Canadian Naturalist and Geologist, Vol. V., p. 67; also Geol. Canada, Report of Progress (1863), page 219, fig. 231.

General outline ovate-sub-elliptic, moderately convex. Cephalic shield nearly semicircular, rather more than twice as wide as long, regularly rounded anteriorly, and nearly straight behind, excepting near the lat-

eral angles, where it curves somewhat abruptly backward, on each side, into the lateral spines, which are small, and scarcely extend farther back than to the second thoracic segment. Glabella, exclusive of the neck segment, about as wide as long, with its lateral margins so nearly straight and parallel, as to make its breadth almost as great anteriorly as behind; separated from the cheeks by narrow but well-defined furrows, that unite around the front so as to leave a very narrow border between its anterior margin and that of the cephalic shield; lateral furrows well defined, and extending inward on each side about one-third the entire breadth; posterior lateral lobes a little smaller than the next two on each side in front of them, and sometimes nearly isolated by the furrows immediately before them, being so oblique as nearly or quite to run into the neck furrow before reaching the middle; succeeding two lateral lobes on each side, nearly transverse; anterior lobe larger, about twice as wide as long, rounded on each side, and somewhat straightened across the front. Neck segment well defined, arched upward so as to be as high in the middle as any part of the glabella in front of it, and wider in the middle than at either end; neck furrow rather distinctly arched forward in the middle. Cheeks sloping anteriorly and laterally from the eyes, with the continuation of the neck furrow along their posterior margins strongly defined, straight, transverse, and terminating laterally some distance within the margins, where they meet, nearly at right angles, a furrow that passes forward on each side to the anterior end of the glabella; outside of the latter, a more shallow furrow also passes around the lateral borders. Eyes of moderate size, scarcely as prominent as the middle of the glabella, situated their own length in advance of the posterior margins of the cheeks, and nearly the same distance from the front of the same; visual surface a little arched, and showing under a good lens, when moistened, very minute reticulations, that seem to be mainly seen *through* the thin crust. Facial sutures starting at the middle of the anterior margin of the head, and cutting rather close around the anterior lateral corners of the glabella; thence extending backward, with a slight outward obliquity, to the eyes, where they make slight curves (to form small, moderately prominent, palpebral lobes) to the posterior end of each eye; from which points they extend outward, at first, with a slight forward obliquity, after which they are deflected backward and outward, so as to cut the lateral margins a little in advance of the points where the continuations of the neck furrow along the posterior margins of the cheeks, would intersect the same, if continued outward.

Thorax about twice as long as the cephalic shield, nearly as wide anteriorly as long, and distinctly trilobate; axial lobe scarcely equaling

the breadth of the lateral lobes anteriorly, and proportionally a little narrower behind, but rather distinctly more prominent and rounded; segments eleven, nearly transverse, and regularly arched upward. Lateral lobes a little flattened on top, nearly half way outward, at which point they slope off rather abruptly laterally; pleuræ straight and transverse for nearly half their length, where they are geniculated, obscurely subnodose, and curve downward and a little backward, to their falcate extremities, which lap upon each other in rolled-up specimens, about half their breadth, each a little thickened, and divided at its inner end, by a short oblique furrow, into two little subnodose prominences.

Pygidium small, transversely sub-elliptic, being twice as wide as long, and broadly rounded in outline behind; axial lobe small, and composed of three obscurely defined segments; lateral lobes large, and composed each of three segments, which terminate at the margin in moderately prominent, somewhat thickened, digitations, the anterior of which are largest, somewhat carinate on top, and strongly curved backward, while the others decrease in size inward to the central two, which are smallest.

Surface finely and obscurely granulated, excepting that of the cheeks, which is sometimes marked with very small pits.

Length of the largest known specimen, 2.15 inches; length of head, 0.62 inch; breadth of do., 1.22 inches; length of thorax, 1.15 inches; breadth of do., 0.60 inch; length of pygidium, 0.37 inch; breadth of do., 0.65 inch.

This species may be so readily distinguished from the common *C. pleurexanthemus* of the same formation, by nearly all of its specific characters, that it is not necessary to compare it with that form. It is much more nearly allied to several European species, but still too distinct to require comparison.

Suspecting that our specimens might belong to Mr. Billings's species, I sent a photograph of one of them to him for comparison, and he wrote back that he had no doubt of its identity with his *C. icarus;* though he noticed that the posterior outline of its pygidium is not so straight across as in his specimens. Subsequently I had an opportunity, through the politeness of Mr. Billings, to make a direct comparison of our specimens with his types, and I fully concur with him in the opinion that there are no specific differences between the Ohio and Canadian specimens. It is worthy of note, however, here, that Mr. Billings's published figure was made out from a small rolled-up specimen, that did not show clearly the lateral extremities of the pleuræ, nor the posterior terminations of the facial sutures. Consequently, his figure represents the ends of the

pleuræ too narrow and straight, instead of falcate; to which fact Mr. B. called my attention. Our specimens also show that the facial sutures curve backward after passing about half way out from the eyes, so as to reach lateral margins farther back than represented in his figure.

Locality and position: Upper part of Cincinnati group, in Butler county, Ohio, and at same horizon at Richmond, Indiana. The rolled-up specimen represented by figure 11 *b*, of pl. 14, belongs to the collection of Mr. U. P. James, of Cincinnati; and the larger one, represented by fig. 11 *a*, of same plate, belongs to the collection of Mrs. M. P. Haines, of Richmond, Indiana, who discovered it at that place. I have also seen either the same, or a very closely allied species, from the Lower Silurian beds at Dixon, Illinois.

Genus ACIDASPIS, Murchison, 1839.

(Silurian System, p. 658.)

Acidaspis crosotus, Locke?

Pate 14, figs. 10 *a*, *b*.

Ceraurus crosotus, Locke, 1842; Am. Jour. Sci. and Arts, Vol. XLIV., page 347, with a wood cut.

Acidaspis crosotus, James, 1871; Catalogue Fossils Cincinnati Group, p. 14.

Body small, with a general subovate or sub-elliptic outline, rather distinctly convex. Cephalic shield sub-semicircular, and rather more convex than the body, apparently rounded in front, with the lateral angles produced into slender, mucronate, somewhat curved spines, that extend obliquely outward and backward to points opposite the fifth or sixth thoracic segment. Glabella, including the neck segment, one-third longer than wide, with an oblong sub-elliptic outline, the widest part being slightly behind the middle and between the eyes; lateral lobes two on each side, of slightly oval outlines, with their longer diameters directed a little obliquely outward and forward, the posterior one being slightly larger than the anterior, while both are separated by as well-defined furrows from the central, rather narrow part of the glabella, as they are separated from each other, or from the cheeks on each side; anterior lobe about as large as all four of the lateral lobes, twice as wide as the narrowed central part of the glabella behind it, and apparently rounded in front; between the lateral lobes and each eye, a kind of outer or supplementary lobe, or protuberance, as large as each two of the lateral lobes, occurs; while from the outer side of each of these protrudes the small prominent palpebral lobe, which arrangement places the small eyes quite remote from each other; eyes unknown, but apparently small,

prominent, and directed laterally; movable cheeks not well preserved in the specimen studied, but apparently narrow, and sloping abruptly from the eyes laterally; neck segment comparatively large, prominent, with a central tubercle, and well defined by the neck furrow, which arches forward in the middle.

Thorax nearly twice as long as the cephalic shield, and about one-fourth wider than long, exclusive of the produced extremities of the pleuræ, with its segments strongly arched upward, but not forward. Lateral lobes comparatively rather depressed, and rounding off gradually toward the lateral margins; pleuræ terminating in mucronate spines directed outward and more or less backward, the posterior ones being longer, and directed more nearly backward.

Pygidium small, and with its mesial lobe composed of about three segments; lateral lobes consisting apparently of about three or four segments, each of which terminates in an acute spine, the lateral ones of which are larger than the others, and curved backward.

Entire surface comparatively rather coarsely granular, the granules being larger on the head than elsewhere; while on each of the pleuræ, a larger granule or very minute tubercle occurs, at a point about half way out to the knee, or geniculation, at which latter point there is also some appearance of another, thus making two rows of these coarse granules along each lateral lobe.

Entire length, exclusive of the spines of the pygidium, about 0.25 inch; length of head, 0.08 inch; breadth, exclusive of lateral spines, 0.15 inch; breadth between eyes, 0.10 inch; length of thorax, about 0.11 inch; breadth of same anteriorly, exclusive of the extended ends of the pleuræ, 0.14 inch.

I am far from being entirely satisfied that this little trilobite is the same species figured by Prof. Locke, under the foregoing name. If his figure is entirely accurate in all its details, the form under consideration would certainly be distinct; but knowing how difficult it is for one not trained to drawing such objects with the degree of precision required by the present more advanced state of natural history, especially such small ones, and the equally great difficulty in getting such drawing accurately cut in wood, I am prepared to believe that he may have had the same species before him. Our specimen is not in a condition to show the digitations along the margins of the cheeks, if they exist. The lateral spines of its cheeks are longer, more slender, and more curved than represented in Dr. Locke's figure, while its neck segment is much thicker in the middle, and the form of the lobes of its glabella entirely

different. The extremities of its posterior pleuræ, and some of the segments of its pygidium, are also much more produced backward. His figure being, as he states, only magnified three diameters, would show that his specimen must have been full twice the linear dimensions of ours. Unfortunately, his whole collection was boxed up, and could not be seen, when I was in Cincinnati during the summer of 1871, so that I have had no opportunity to compare the form here figured with his type, which he did not describe in detail.

I have before me another specimen of a still smaller size, belonging to Mr. James's collection, and from a higher position in the series, that seems to be the same as the foregoing, though it may possibly be distinct, as the number and arrangement of the spines of its pygidium are different. It is represented by our figure 10 *b*, of plate 14. It shows the inner side of the dorsal crust, as seen lying in a dark shaly matrix. This shows minute digitations around the margins of the cheeks (13 or 14 to each side), and has the same slender arched spine at the posterior angle of each cheek. The free ends of its pleuræ are very slender and much produced. This specimen is not in a condition to show the eyes, or the details of its glabella.

Locality and position: Cincinnati group, Cincinnati, Ohio. The specimen represented by figure 10 of plate 14, belongs to Dr. C. A. Miller, of Cincinnati, who found it in one of the lowest beds exposed there. The other, represented by figure 10 *b*, of the same plate, belongs to Mr. U. P. James, of Cincinnati, and was found by him there at a horizon of about 150 feet above low-water mark of the Ohio river.

Acidaspis Cincinnatiensis, Meek.

Plate 14, fig. 3.

Cephalic shield, and most of the thorax, unknown. Pygidium, exclusive of its spines, about three times as wide as long, and approaching a sub-semicircular outline; its anterior margin being straight all the way across, and about one-third of its posterior margin in the middle transversely truncated, while on each side of this the posterior lateral margins are straight to the anterior lateral angles; mesial lobe prominent at the anterior end, where it is about as wide as each lateral lobe, but becoming rapidly depressed and narrowed posteriorly, composed of only two well defined segments; lateral lobes flat, excepting a ridge that extends obliquely backward and outward from the anterior segment of the mesial lobe, across each, to the posterior lateral margins, where these ridges terminate in prominent, rounded, diverging spines; while the posterior lateral margins between these spines and the lateral angles,

are each armed with four smaller slender spines directed obliquely backward and outward; four similar smaller spines also occupy the truncated middle part of the posterior margin between the two larger ones. Surface smooth, excepting a few very minute scattering asperities on the spines.

Of the thoracic segments, the posterior one, and a part of the next one in advance of it, are seen in connection with the pygidium in the matrix. These show that the posterior extremity of the mesial lobe of the thorax is about as wide as the lateral lobes, moderately arched upward (not forward), and nearly or quite smooth, while the lateral lobes are flat. The pleuræ of the posterior thoracic segment are smooth, and have each a strong mesial ridge extending straight outward to the lateral extremity, where it curves abruptly backward, and is produced into a long, sharp spine, extending as far backward as the longest spines of the pygidium, or farther. The anterior margin of each of these pleuræ has also the character of a more slender, depressed marginal ridge, that likewise terminates in a backward curve, but much smaller lateral spine, just in front of the larger one, while there is behind the larger mesial ridge a narrower, flat margin, that runs out to nothing before reaching the outer extremity.

Length of pygidium, exclusive of spines, 0.19 inch; breadth of do., 0.55 inch. Transverse diameter of first thoracic segment in advance of pygidium, 0.70 inch; length of each pleuræ, 0.23 inch; anterio-posterior diameter of the same, 0.08 inch; length of larger lateral spine of each, 0.38 inch.

That this species is distinct from the form I have referred to Dr. Locke's *A. crosotus*, seems to be evident, not only from its much larger size, but because it shows no traces of the rather distinct, closely set granulations seen on all parts of that species, and differs in other details. In many respects, it appears to be closely related to *A. Prevosti* of Barrande, so far as we have the means of comparison; but still it wants the distinct surface granulations of that form, and hence would doubtless be found to present other differences, if we had the entire fossil to compare.

I have also before me, a right, movable cheek of an *Acidaspis* from Cincinnati, that may, judging from its size and general appearance, belong to this species. Its posterior extremity is produced in the form of a long, stout, rounded spine, covered with little asperities, while the margin of this cheek is armed by about twelve short digitations. The inner or under side of this specimen is represented by our figure 4, of plate 14. Fig. 5 of the same plate, represents the inner side of another similar

cheek, with a more slender terminal spine, longer digitations, and a greater breadth between the eye and the digitate margin, from a higher position in this series, at Dayton, Ohio.

Mr. James's collection also contains two specimens of the glabella of one or two species of *Acidaspis*, with a long spine projecting backward from the occipital portion. These are represented by our figures 6 and 7 of the same plate. They differ enough in details to belong to two distinct species, and yet may belong to varieties of the same form. Of course, without other specimens showing these parts in connection, it is not possible to determine what relations they may bear to the pygidium for which I have proposed the name *A. Cincinnatiensis*. I suspect, however, that one or the other, or both, belong to that species, and yet they may be quite distinct from it. It was evidently to one of these forms that Dr. Locke referred, in Vol. XLV., p. 223, of the Am. Jour. Sci. and Arts, published in 1843, as possibly belonging to his *A. crosotus*. They are certainly distinct from that form, however, not only in their much larger size, and the possession of the long appendage to the back part of the head, but in the form and comparative sizes of the lateral lobes of the glabella. They seem to be related to *A. Grayi* of Barrande, though differing in details.

If these specimens should be found to belong to a distinct species from any of those yet named, I would propose for it the name *Acidaspis rhyncocephalus*, in allusion to the beak-like appendage of the back of the head.

Locality and position: The pygidium for which I have proposed the name *A. Cincinnatiensis*, belongs to Mr. Dyer, who found it at Cincinnati, at the horizon of about 100 feet below the tops of the hills. The cheek represented by figure 4, of the same plate, was also found at Cincinnati by Mr. James; and that represented by fig. 5 belongs to Mr. O'Neall, of Lebanon, Ohio, and was, I believe, found by him near that place, in the upper part of the Cincinnati group. The two specimens of glabella, illustrated by figures 6 and 7 of the same plate, were found by Mr. James, at about 15 to 20 feet above low water of the Ohio, at Cincinnati; but he informs me that he has found the same forms as much as 200 feet higher in the series at that city.

Acidaspis ceralepta, Anthony (sp.)?

Plate 14, figs. 8 and 9.

Ceratocephala ceralepta, Anthony, 1838; Am. Jour. Sci., Vol. XXXIV., p. 379, figs. 1 and 2.

Among the specimens from Cincinnati loaned to me by Mr. James, there are two of the pygidium of one or two species of *Acidaspis*, that

probably belong (one or both) to the form for which Mr. Anthony proposed the above name. They have a sub-semicircular or transversely semi-elliptic form, and are each provided with two long diverging spines behind, and three much shorter digitations on each posterior lateral margin. They differ, however, in the proportional size of the posterior spines; and one (fig. 8) shows no digitations on the posterior margin between the spines; while the other (fig. 9) has about six very short, little projections there.

Mr. Anthony's figures, being rough wood-cuts, do not show the digitations clearly, but as he describes his species as having the margin crenulated, his specimens must have shown some such character. It is possible that the form for which I have proposed the name *A. Cincinnatiensis*, may not be distinct from this; but from its larger size, proportionally much longer marginal digitations, and smoother surface, I think it probably distinct. If comparisons of much better specimens, however, should show them all to belong to one species, Mr. Anthony's specific name, having priority of date, ought to be adopted. The fact that he mistook the pygidium for the head, and the posterior spines for antennæ (a pardonable error, at that early day, when these trilobites were only known as detached fragments), is no reason, I should think, why his specific name should be rejected, although such has been the practice, in similar cases, with some distinguished naturalists.

Locality and position: Cincinnati group, at Cincinnati, Ohio. Ranges, according to Mr. James, from 20 feet to 350 below low-water mark of the Ohio, at Cincinnati.

Genus DALMANITES, Barrande, 1852.*

(Silur. Syst. Boh. I., Explanation, pl. 21, etc.)

Dalmanites Carleyi, Meek.

Plate 14, figs. 2 *a*, *b*, *c*, *d*.

Dalmanites Carleyi, Meek, 1872; Amer. Jour. Sci. and Arts, Vol. III. (3d ser.), p. 424.

Size small; general outline unknown, but probably ovate. Cephalic shield about twice as wide as long, rounded in front, and more or less straight behind, so as to present a nearly semicircular outline, exclusive

* Emmrich described this genus under the name *Dalmania*, in 1845; but as that name was preoccupied for several genera of Insects, etc., I prefer to use *Dalmanites*, which was, I believe, first published by Barrande, as cited above, though he used it as a mere modification of Emmrich's name.

of the produced posterior lateral extremities, which are about as long as the glabella, rather broad anteriorly, and tapering rapidly to the posterior ends. Glabella wide in front and rapidly narrowed behind, defined by a moderately distinct furrow on each side, and not very prominent at any point; anterior lobe comparatively large, transversely elliptical or sub-rhombic; lateral lobes small, and separated by furrows that extend inward so as to leave only a very narrow central space; anterior pair each sub-trigonal, about twice as large as the middle lobe, which is transversely ovate, while those of the third or posterior pair are smallest; neck-furrow moderately well defined, and continued as posterior marginal furrows of the cheeks nearly to their outer margins; occipital segment comparatively rather wide anterio-posteriorly, and elevated and convex in outline behind; palpebral lobes ascending and narrowing rapidly outward to the summit of the eyes. Cheeks sloping laterally from the eyes, rather abruptly, to a shallow marginal furrow, that is continued so as to form a very narrow margin around the front of the glabella. Eyes moderately large, situated full half their length from the posterior margins of the cheeks, and elevated somewhat above the height of the glabella, truncato-sub-conical in form, the visual surface curving around so as to form about three-fourths of a circle at its base; lenses of comparatively moderate size, showing about seven in a vertical row at the middle, and twelve or fourteen in the longest oblique rows. Surface of anterior lobe of glabella showing small, obscure granulations; other parts of the cephalic shield nearly smooth, or less distinctly granular.

Thorax unknown. Pygidium sub-trigonal, rather depressed, as wide as long, or a little wider, very narrowly rounded, or almost sub-angular behind, the posterior extremity being curved a little upward; mesial lobe depressed, but a little more convex than the lateral, and of about the same breadth, or slightly narrower, at the anterior end, and narrowing to the posterior extremity, which does not reach the margin, composed of about thirteen distinct segments, and two or three other very small obscured ones behind these; lateral lobes separated from the mesial lobe by moderately distinct furrows, and sloping off gently, with slight convexity of outline, to the lateral and posterior margins, showing each about thirteen segments, which are not furrowed, and extend very nearly, but not quite, to the margin, the smaller posterior ones being directed very obliquely backward; surface showing rather fine, irregular scattering granules.

Length of cephalic shield, exclusive of the posterior lateral spines, 0.35 inch, including do., about 0.60 inch; breadth, 0.67 inch; anterio-posterior diameter of eyes, 0.12 inch; height of same on outer side, 0.08

inch. Length of a detached pygidium of apparently about corresponding size, 0.42 inch; breadth of do., about 0. 48 inch.

It is not absolutely certain that the cephalic shield and pygidium here described belong to the same species; but as several specimens of each have been found in the same beds together, and they correspond well in size and surface granulation, there is very little reason for doubting that they belong to the same trilobite.

This species has, I believe, sometimes been referred to *D. callicephalus*, Hall, from the New York Trenton group; but it differs materially from the figures and description of that species, which represent the posterior lateral angles of the cephalic shield as being each merely produced "into a broad, rounded, wing-like expansion," instead of terminating in long pointed spines. That species also has the eyes represented proportionally longer, nearer the posterior margin, and each only forming about a semicircle; while in the form under consideration, they curve around so as to form quite three-fourths of a circle. The surface of the cephalic shield of our species is also much less distinctly granulated. There are likewise equally well-defined differences in the pygidium found associated with the cephalic shield of our species, which shows in each lateral lobe thirteen well-defined segments, without sulcations; while in *D. callicephalus* these lobes are described as having each only nine segments, with strong furrows.

At one time I was inclined to think this might be the form published by Prof. Hall under the name *D. breviceps*, although I noticed that it differed in several respects from the characters given in the description of that species. Since seeing the figure of that form, however, recently published, I am satisfied that our specimens belong to an entirely distinct species. The differences distinguishing these two forms are the following: In the first place, the anterior lobe of the glabella of our species has a more nearly rhombic form, its lateral extremities being much more narrowly rounded. Again, its glabella differs in having three well-defined pairs of lateral lobes instead of only two, the anterior pair being as large as both of the others, and each triangular in form. The neck-segment of our spines likewise differs in being fully twice as thick as that of *D. breviceps*, while its palpebral lobes have an entirely different form, and its eyes are decidedly more strongly curved, and farther removed from the posterior margins of the cheeks.

The specific name was given in honor of S. T. Carley, Esq., formerly of Cincinnati, and one of the earliest and most successful collectors and students of the Cincinnati fossils.

Locality and position: Cincinnati, Ohio, where it was found by Mr. U. P. James, in the Cincinnati group of the Lower Silurian, at the horizon of about 300 feet above low-water mark of the Ohio river.

Genus CALYMENE, Brougniart, 1822.

(Crust. Foss., p. 9.)

Calymene senaria, Conrad.

Plate 14, figs. 14 *a, b, c, d, e, f.*

Calymene Blumenbachii, Green (in part), 1832; Monograph, p. 28, and cast No. 1; and of many others (not of Brougniart, 1822).

Calymene senaria, Conrad, 1841; Ann. Report Geol. N. Y., p. 49; Emmons, 1842, Geol. Rep., p. 390, fig. 2; Hall, 1847, Palæont. N. Y., Vol. I., p. 238, pl. LXIV., figs. 3 *a–n;* Salter (1865), Monogr. Brit. Trilob., p. 97, pl. IX., figs. 6–11 (as *var. C. Blumenbachii*).

Calymene brevicapitata, Portlock, 1843; Geol. Report Londonderry, etc., p. 286, pl. III., fig. 3; Salter (1848), Mem. Geol. Survey, Vol. II., 341, pl. XI., figs. 1, 2; and Vol. III., pl. 17, figs. 10–12, not 9; McCoy (1865), Palæozoic Fossils Woodw. Mus., 165, tab. 1 F, figs. 4–6.

Calymene forcipata, McCoy, 1846; Sil. Fossils Ireland, pl. IV., fig. 14.

Calymene Bayleyi, McCoy, 1865; Pal. Fossils Woodw. Mus., tab. 1 F, figs. 4–6.

General form subovate, the length being usually about one and a half to one and three-fourths the breadth; convexity rather more than one-third the breadth.

Cephalic shield, as seen in a direct view from above, sub-semicircular, approaching sublunate, the anterior outline being more or less nearly regularly rounded, and the posterior broadly sinuous, with the posterior lateral extremities bluntly sub-angular, or abruptly rounded. Glabella more prominent than the cheeks or eyes, about as wide behind as its length, including the neck segment, very strongly defined from the cheeks and the front margin (which latter is very prominent, and strongly recurved and arched upward in the middle) by profound furrows; lateral lobes, particularly the posterior two pairs, distinctly defined by deep lateral furrows that curve a little backward, the posterior pair being transversely, or obliquely, a little oval, and about three times as large as those of the next pair, which are as much larger than the third pair, all being nearly round; neck furrow well defined; neck segment about of the same size as the first thoracic segment, often slightly thickened at each end, arched a little forward, and nearly or quite as high as the most prominent part of the glabella in front. Eyes rather prominent, small, nearly surrounded, excepting on the inner side, by a shallow con-

cavity, and situated opposite the furrows between the anterior and middle lateral lobes of the glabella; visual surfaces very small, about twice as long as high, a little arcuate, and directed nearly laterally; palpebral lobes small, rather prominent, and capping, as it were, the visual surfaces. Movable cheeks, with thick, rounded, lateral margins, defined by a distinct, rounded marginal furrow, continuous with that separating the anterior end of the glabella from the prominent, arched middle of the anterior margin. Fixed cheeks, provided with a very deep, broad furrow along their posterior margins. Facial sutures directed forward anteriorly, so as to intersect the margins somewhat nearer together than the breadth across between the eyes; posteriorly, sometimes slightly furrowed, and directed at first a little obliquely backward and outward from the eyes, for less than half their length, then curving somewhat abruptly, and extending more obliquely backward, nearly straight to, or very slightly in front of, the posterior angles of the cheeks; rostral shield strongly arched, about twice and a half as long, measuring directly across from its lateral extremities, as the height from its upper to its lower margin, at the middle. Labrum or hypostome longitudinally oblong, with sinuous lateral margins; anterior end a little wider than any other part, with a convex outline; anterior margin prominent, rather deeply notched in the middle, with a projecting point on each side of the notch. Internal surface concave; external, convex and smooth.

Thorax about twice the length of the middle of the cephalic shield, narrowing backward, and very strongly trilobate; mesial lobe as wide as the lateral, and distinctly more convex, rounded or somewhat depressed on top, and having its thirteen segments usually a little thickened at their ends, but without nodes. Lateral lobes separated from the middle one by distinct furrows, somewhat flattened on the inner third, and rounding off more or less strongly to the lateral margins; pleuræ extending straight outward for about one-fourth to one-third of their length, and then slightly deflected and curved backward to their outer ends, which are rounded, compressed, somewhat expanded, and provided with a thickened marginal ridge (not seen externally), while the anterior faces of their outer halves are strongly flattened or beveled for sliding upon each other in rolling up; each with its longitudinal furrow well defined, and placed so as to divide off, as it were, its anterior third, though this is not seen more than half way out from their inner ends, when the thorax is folded together.

Pygidium one-half to two-thirds the length of the middle of the cephalic shield, wider than long, with a more or less nearly sub-trigonal outline, the anterior margin, however, generally being so rounded as to impart a

nearly transversely suboval form to the general outline; mesial lobe well defined, depressed convex, and extending very nearly to the posterior margin, showing five or six segments, the last two being very faintly defined, while behind those there is space enough for two or three more. Lateral lobes sloping or curving off more or less rapidly, each with about five segments, only the anterior one of which has a furrow like that of each of the pleuræ.

Entire surface finely and evenly granular.

Length of cephalic shield (at its middle), 0.52 inch; greatest breadth at the posterior angle of the cheeks, 1.08 inches; length of glabella, exclusive of neck segment, 0.34 inch; breadth of glabella, 0.32 inch. Length of thorax, about 1 inch; breadth at anterior, about 0.97 inch; breadth of anterior end of mesial lobe, 0.35 inch. Length of pygidium, 0.36 inch; breadth of same, 0.50 inch.

This common, and beautiful trilobite, is regarded by many as only a variety of *Calymene Blumenbachii*, Brougniart, which may be the case, as the characters in which it differs from that species are not very striking. Its most obvious differences consist in its more finely and evenly granulated surface, and smaller sizes; the *C. Blumenbachii* having its surface marked by granulations, with tubercles, or larger granulations mingled with the smaller, and attains a rather decidedly larger size. There are also some other more or less important differences of details, such as the more produced and reflexed front margin of the head of *C. senaria*, the proportionally rather broader base of its glabella, and the more anterior position of its eyes.

Whether such differences should be regarded as being of specific, or only sub-specific importance, is, to some extent, a matter of taste, or perhaps more properly speaking, depends upon one's views in regard to the degrees, or kinds of differences, that should be considered specific. However this may be, it seems desirable, in the present state of our knowledge of these forms, to keep them separate.

Locality and position: In New York, as well as at various localities in some of the adjoining States, and Canada, this fossil occurs in the Trenton limestone, and ranges up into the Niagara group. It also has the same range in several of the Western States. At Cincinnati, Ohio, it ranges through the lower and middle portions of the Cincinnati group; and at Oxford, Lebanon, and various other localities in that State, as well as at Richmond, Madison, and numerous other places in Indiana, it occurs in the higher parts of the same series. It has also been identified in England and other foreign countries. For the use of the very fine entire specimen of this species, figured on our plate, I am indebted to D. H. Shaffer, Esq., of Cincinnati. Those showing the separate parts belong to Mr. Dyer.

FOSSILS OF THE NIAGARA AND CLINTON GROUPS.

MOLLUSCA.

BRACHIOPODA.

Genus TRIPLESIA, Hall, 1859.

(12th Ann. Report Regents, p. 44 (=*Dicraniscus*, Meek, 1872).

Shell transversely or longitudinally sub-oval, generally more or less trilobate; hinge line straight, and provided with teeth and sockets. Ventral valve with a rather deep, rounded mesial sinus, that often terminates anteriorly in a rounded marginal projection; provided with a well-defined cardinal area, divided in the middle by a triangular fissure; beak imperforate; hinge with a strong tooth on each side of the fissure, merely supported by the thickening of the interior of the cardinal region, and apparently without any well-defined dental laminæ; muscular impressions small, situated in the bottom of the valve, and without raised margins. Dorsal valve having a more or less prominent mesial fold that imparts the usual trilobate appearance to the shell; cardinal margin not provided with an area, but having a prominent bifurcating cardinal process, on each side of which there is a brachial process, directed obliquely inward and laterally; and between the outer side of each of the latter and the cardinal edge, there is a socket for the reception of the teeth of the other valve; muscular impressions small, and placed in the bottom of the valve without raised margins. Surface nearly smooth, or only showing marks of growth, and, perhaps, sometimes, obscure radiating striæ.

At the time I proposed the name *Dicraniscus* for this type, I had only seen fragmentary specimens, which gave but a very limited knowledge of the form and general physiognomy of the exterior of the shell; though they clearly showed that it possessed quite different internal characters from any that had been described or illustrated in any of the established genera. On the contrary, the specimens on which Prof. Hall

founded the genus *Triplesia*, showed perfectly all of the external, but none of the internal characters; so that his generic description and illustrations only made known the exterior of the shell. If I had seen but a single entire specimen of our shell, or if Prof. Hall had described or illustrated the internal characters of his genus, I would certainly (especially in the latter case) have at once referred our shell to the same, if I am correctly informed in regard to the interior of *Triplesia*.

Almost immediately after the publication of my generic description, a friend who had been in correspondence with Mr. Whitfield, informed me that specimens of some of the typical species of Prof. Hall's genus *Triplesia* had recently been found in New York, showing that it possesses essentially the same internal characters as our Ohio shell. This being the case, the generic identity of the forms for which the two names were proposed would seem to be clearly established; and, as both names cannot be retained for the same genus, I now provisionally withdraw *Dicraniscus;* though I am not sure that the rules of nomenclature may not yet require it to be retained, instead of *Triplesia*.

The objection to the name *Triplesia* is, that *Triplasia* had been used by Reuss for a genus of *Foraminifera*, in 1854.* *Triplesia* and *Triplasia*, however, are not *exactly* identical; and although it is undesirable to propose a new name so near one already published for another genus, when this has inadvertently been done, I think, in general, both names should be allowed to stand, even when there is only a difference of one letter, unless that difference is due to a mere error in the orthography of one of the names, which, if correctly written, would make it exactly the same as the other. This, however, is the case with *Triplesia*, which, if correctly written, would become *Triplasia;* and, consequently, I should think, it ought not to stand, if Reuss's genus is a good one.

Prof. Hall gives the etymology of *Triplesia*, as follows: "[Gr. τριπλασιος, *triplex;* in reference to the trilobate character of several of the species.]" As τριπλασιος and *triplex* are not synonymous (the latter being equivalent to τριπλεκης, Latinized *tripleces*), there is an evident inconsistency between the name used and the character it was intended to express, though this doubtless resulted from a typographical error or a slip of the pen.

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* *Triplasia* also occurs in lists of plants for an older genus of Grasses, but probably not for a good genus. At any rate, there seems scarcely any sufficient reason why the same name may not be used both in Botany and Zoology, without creating confusion, though contrary to the rules of the British and American Associations for the Advancement of Science.

Triplesia Ortoni, Meek.

Plate 15, figs. 1 *a* to *k*.

Dicraniscus Ortoni, Meek, 1872; Am. Jour. Sci. and Arts, Vol. IV. (3d series), p. 280.

Shell apparently truncato-sub-oval, or sub-orbicular in general outline, being sometimes longer than wide, but more frequently the reverse, with the widest part in front of the middle, becoming quite gibbous in adult examples; hinge line generally, if not always, less than the breadth of the valves. Ventral valve less convex than the other; mesial sinus deep and wide anteriorly, but not extending quite to the beak; cardinal area rather low, sharply defined, and standing nearly at right angles to the plane of the valves, or sometimes a little arched backward; beak small, and scarcely projecting beyond the area, its point being slightly arched in some specimens. Dorsal valve moderately convex, rising into a more or less prominent mesial fold; umbo rather prominent, or at least projecting beyond that of the other valve, though the immediate and very obtuse point of its beak is incurved to the hinge line; cardinal process very long, a little curved, rounded, and rather slender below, and divided above, nearly half its length, the divisions being slender, diverging, and somewhat furrowed on their posterior sides above. Surface nearly smooth, or only showing a few sub-imbricating marks of growth near the free margins.

The specimens yet known to me are too imperfect to afford detailed measurements, though they indicate a length of one inch and a quarter, and a breadth of one inch or more.

I had examined many specimens of this shell, consisting of only the thickened rostral parts of the separated valves, showing the very long cardinal process of the dorsal valve, and the hinge and area of the ventral, before I could believe that they really belonged to the same shell. It was difficult to comprehend how so very long a cardinal process as that possessed by the dorsal valve, could be received into a ventral valve with no deeper concavity than those found in such association as to indicate that they ought to belong to the same species. It was, therefore, not until Prof. Orton found a broken specimen, with portions of the two valves united, and showing this long process in place, with relation to both valves, that I was aware that the beak of the dorsal valve is so incurved as to give this process a very oblique forward direction within the opposite valve.

I have seen no specimen with the anterior margins well enough preserved to show whether or not the mesial fold and sinus project forward beyond the margins on each side, as in the other species of the group; but so far as can be determined from the direction of the lines of growth, there would seem to be no projection of the anterior margin there. The fragments of the rostral parts, most usually found, belong to the dorsal valve. They are generally quite thick, and retain more or less of the cardinal and brachial processes. Some of them show two small, rather deep, closely approximated muscular impressions, in the bottom of the valve, with a short little ridge between them. There also seem to be one or more obscure scars on each side of these. In front of these muscular impressions, the valves seem to be quite thin.

In size and general appearance, perfect specimens of this species probably most nearly resemble *T. cuspidata*, Hall,* from the central part of the Trenton group, at Lowville, New York. It differs, however, in having a straighter and longer hinge line, and more developed cardinal area, a less elevated mesial fold, and in showing no traces of radiating striæ.

The specific name was given in honor of Prof. Edward Orton, of the Ohio Geological Survey, who discovered the specimens.

Locality and position: Near Dayton, Ohio, from the summit of the Clinton group of the Upper Silurian.

Genus RHYNCHONELLA, Fischer, 1809.

(Mem. Soc. Imp. Mosc. II.)

Rhynchonella neglecta, Hall.

Plate 15, figs. 3 *a, b, c, d.*

Atrypa neglecta, Hall, 1852; Palæont. N. Y., Vol. II., p. 70, pl. 23, figs. 4 *a–f.*
Rhynchonella neglecta, Hall, 1859; 12th Report of Regents, p. 78.
Rhynchonella neglecta, var. scobina, Meek, 1872; Am. Jour. Sci. and Arts, Vol. IV. (3d series), p. 277.

Shell rather small, sub-trigonal, compressed, or sometimes in large specimens quite gibbous, with the mesial fold very prominent and narrow. Dorsal valve bearing on the mesial fold four simple plications, the middle two of which are more prominent and larger than the others, one of which latter occupies each slope of the fold; lateral slopes each provided with about six angular, simple plications; beak incurved.

* *Atrypa cuspidata*, Hall; Palæont. N. Y., Vol. I., p. 138, pl. XXXIII., figs. 1 *a–h.*

Ventral valve with mesial sinus corresponding to the fold of the other valve, and bearing three plications, the middle one of which is usually larger than the others; lateral slopes each with about six plications; beak small, pointed and arched, but not strongly incurved, projecting moderately beyond that of the other valve. Surface of both valves ornamented by fine marks of growth, and numerous, minute, distinct, regularly disposed granules.

Length of one of the largest and most gibbous specimens, 0.55 inch; breadth of do., 0.50 inch; convexity of same, 0.53 inch. Some other individuals of near the same length and breadth have a convexity of only 0.25 inch.

This shell agrees so closely in form, as well as in the number and arrangement of its plications, with *R. neglecta*, Hall, from the New York Niagara and Clinton groups, that I have not felt warrantable in separating it specifically. If that shell, however, has been correctly figured and described from well-preserved specimens, showing all of its finer surface markings, ours ought to be clearly distinct, as there are no surface granulations illustrated in the figures or mentioned in the descriptions of the New York species; while they are *quite distinct, and beautifully defined*, on our specimens. As the New York Niagara fossils are usually found in a good state of preservation, it is improbable that such a character would have been entirely overlooked in *R. neglecta*. Having no authentic specimens of that species at hand for comparison, however, I have merely placed our shell as a variety of the same.

Note.—Since the foregoing was written, I have had (through the politeness of Prof. Hart, of Cornell University,) an opportunity to examine some good specimens of *R. neglecta*, from Lockport, New York; and I find that, on protected parts of the surface, they show some remains of extremely fine granulations. This being the case, I withdraw the name *var. scobina* for the Ohio shell.

Locality and position: Clinton group of the Upper Silurian, at Dayton, Ohio.

Genus MERISTELLA, Hall, 1860.

(Twelfth Report Regents, p. 78.)

Meristella (? Meristina) cylindrica, Hall (sp.).

Plate 15, figs. 2 *a*, *b*, *c*, *d*.

Atrypa cylindrica, Hall, 1852; Palæont. N. Y., Vol. II., p. 76, pl. 24, figs. 2 *a* to *g*.

Shell attaining a rather large size, varying from a moderately compressed, more or less broadly ovate outline, to a much more gibbous,

elongated, sub-cylindrical form, the young shell being proportionally broader and more compressed, and the adult more convex and elongated; anterior margin somewhat compressed, narrowly rounded, and a little raised along the middle; lateral margins, in the young shell, proportionally more convex in outline, and converging and rounding to the front, with usually a slight straightness or flattening of outline, and posterior convergence behind, the latter character often becoming very strongly developed in large adult examples.

Dorsal valve somewhat less convex than the other, its greatest convexity being behind the middle, while its anterior slope is sometimes slightly raised, so as to form a very obscure, or scarcely perceptible mesial ridge; or, in other examples, evenly rounded over from side to side; beak regularly incurved.

Ventral valve with its greatest convexity a little farther back than that of the dorsal, forming a regularly decreasing curve from the beak to the front; anterior slope usually showing a shallow mesial sinus (sometimes merely represented by a slight flattening) that extends to or behind the central region, with an obscurely impressed, nearly linear furrow, along its middle; beak not very prominent, abruptly pointed, and strongly incurved upon that of the other valve.

Surface usually appearing smooth, but, on closer examination, showing obscure striæ of growth, and sometimes extremely faint traces of radiating lines, near the front and lateral margins.

Length of a large, elongated, gibbous specimen (with outline of lateral margins strongly flattened), from the front to the beak of the dorsal valve, 1.25 inches; do., from front to beak of ventral valve, 1.30 inches; breadth a little in advance of the middle, 0.76 inch; convexity, 0.77 inch; same measurements of a young ovate specimen, respectively, 0.67, 0.75, 0.66, and 0.42 inch.

The specimens of this species found in Ohio are often much larger and more robust than those figured in the New York Report; but agree so closely in nearly all their characters, as to leave little room to doubt their identity with the New York shell. The largest individuals, in some cases, have the flattening of the lateral margins much more strongly defined (almost as if by accidental lateral compression, though evidently natural,) than any of those figured by Prof. Hall; which peculiarity gives them a different outline, as seen in a direct view of either valve. As there are, however, all gradations in this flattening, between these and the common forms of the *M. cylindrica*, no separation can be made on this character.

I know nothing of the internal characters of this species, beyond the fact that it has internal spires, and a strong mesial septum, or prominent ridge, in the beak of the dorsal valve.

Locality and position: Hillsboro, Ohio; Niagara group of the Upper Silurian.

Genus TRIMERELLA, Billings, 1862.

(New Species Lower Sil. Fossils, p. 166.)

Trimerella grandis, Billings.

Plate 16, figs. 2 *a*, *b*.

Trimerella grandis, Billings, 1862; New Sp. Lower Sil. Foss., p. 166, figs. 151 *a*, *b*; Dall (1871), Am. Jour. Conch., Vol. VII., p. 82; Davidson and King (1872), Trimerellidæ, p. 4, extr. from Geol. Mag., Vol. IX.; Hall and Whitfield (1872), Notes on some New or Imperfectly Known Forms among the *Brachiopoda*, etc., p. 4, pl. 13, figs. 11 to 16.

Shell (as determined from internal casts) ovate, with valves moderately and nearly equally convex, and the greatest breadth in advance of the middle; lateral margins nearly straight, sub-parallel along the middle, and rounding rather abruptly into the rounded front, while the posterior lateral margins converge abruptly to the beaks. Dorsal valve with its beak apparently short and moderately incurved; interior with the two cylindrical chambers small, and short, or not usually extending back more than to points two-thirds of the length of the valve from its anterior margin. Ventral valve with beak straight, more or less abruptly pointed, and apparently projecting moderately beyond that of the other valve; internal chambers comparatively small, and of about the same length as those of the other valve. Surface and other characters unknown.

Length of internal cast, about 2.40 inches; breadth of do., 2 inches; convexity, 0.90 inch. Mr. Billings mentions seeing specimens 3 inches in length, by about 2.50 inches in breadth.

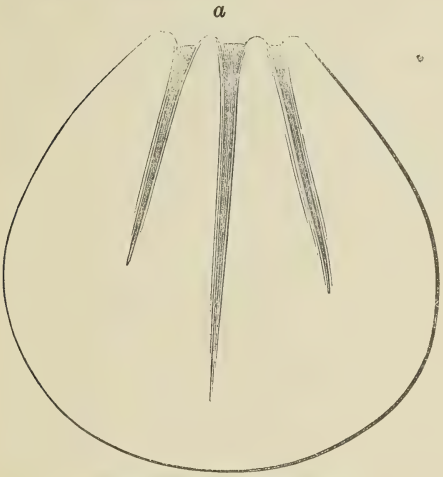
Our figures of this species on plate 16 were drawn from one of Mr. Billings's typical specimens, kindly loaned by him for comparison; but I have since received by Prof. Orton a well-defined specimen of the same shell from an Ohio locality.

Locality and position: Mr. Billings's specimens were from Galt, New Hope and Elora, Canada, where they occur in the Guelph formation (Middle Silurian) of the Canadian Section. The Ohio specimen came from beds referred to the Niagara group of the Upper Silurian, in Ottawa county, Ohio.

Trimerella Ohioensis, Meek.

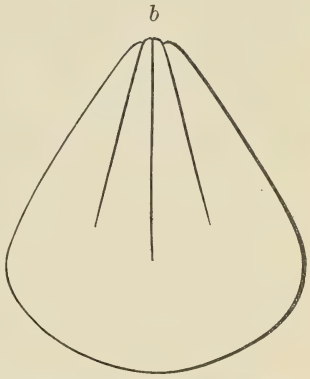
Plate 16, figs. 1 *a*, *b*, *c*, and the annexed cuts.

Trimerella Ohioensis, Meek, 1871; Am. Jour. Sci. and Arts, Vol. I. (3d series), p. 315; Davidson and King (1872), Trimerellidæ, p. 4 (extracted from the Geological Magazine, Vol. IX.).



Trimerella Ohioensis, Meek.

a An outline internal cast of the ventral valve, showing by comparison with figure (*a*) its broader, more rounded form, less attenuated beak, and more widely separated internal cavities.



Trimerella acuminata, Billings.

b An outline of an internal cast of the ventral valve, showing its sub-trigonal form, attenuated beak and (owing to the thinness of the partitions) the closely approximated character of casts of the internal cavities. From a Canadian specimen sent by Mr. Billings, a part of one side being restored in the figure.

Shell attaining a large size; internal cast very broad ovate, the widest part being in advance of the middle, where the breadth sometimes nearly or quite equals the length, rather distinctly convex, in large examples; anterior margin broadly rounded in outline; anterior lateral margins rounding regularly into the front, while the posterior lateral converge rapidly, with somewhat straightened or moderately convex outlines, to the beaks. Dorsal valve more convex than the other, its greatest convexity being behind the middle, thence rounding abruptly over to the umbo behind, and more gradually forward and laterally; beak (of the shell) very strongly incurved, directed downward at right angles to the plane of the valves, and apparently occupying a broad sub-trigonal sinus, or recess in the cardinal margin of the other valve; interior with mesial septum dividing the two characters, strong, extending forward usually about five-sixths the length of the valve, with the chamber on each side of it large, elongated, or extending nearly as far back as the cardinal margin, more or less obtusely pointed, and distinctly arched with the

curve of the valve. Ventral valve more flattened in the umbonal region, with beak apparently straight, moderately prominent, and rather abruptly pointed; interior with mesial septum extending as far forward as that of the other valve, and the mesial chambers long, or extending backward a little beyond the hinge margin, and nearly straight or only a little arched; while between these and each posterior lateral margin, a shallow lateral cavity extends about as far back as the mesial chambers. Margins of the two valves meeting without any upward or downward curvature around the front, but their line of junction along each posterior lateral region is broadly waved upward. Surface, as determined from moulds of the exterior in the matrix, marked by concentric striæ, which become rather strongly defined, regularly disposed, and subimbricating around the anterior and lateral margins.

Length of a large internal cast, 3.50 inches, with a breadth of about 2.65 inches, and a convexity of 2 inches.

At the time I first indicated this form, in the Journal of Science, I had but a very limited knowledge of Mr. Billings's *T. acuminata*, which had only been illustrated and described from a cast of the rostral part of the ventral valve. From Mr. Billings's figures, I then supposed our Ohio specimens to be allied most nearly to his *T. grandis;* though they are readily distinguishable from that species by their broader form, much longer internal chambers, and decidedly more strongly incurved beak of the dorsal valve, as shown in our figures of the two forms on plate 16. Since that time, Mr. Billings has more fully characterized his *T. acuminata*, from better specimens than those first studied by him; and he has also kindly sent to me specimens of the same from Canada. From his more extended description, and the specimens sent by him, it becomes clearly evident that our Ohio shell is decidedly more nearly related to his *T. acuminata* than to his *T. grandis.* Wishing to have our specimens as thoroughly compared with Mr. Billings's types as possible, I loaned them to him for that purpose, and he wrote back that, although closely related to his *T. acuminata*, he thinks the *T. Ohioensis* still a distinct species.

The principal differences between these two forms, so far as yet known, seem to consist in the more narrow sub-trigonal form, and the more produced and acuminate character of the beak of *T. acuminata;* which also has the casts of its internal cavities more slender, more elongated, and more closely approximated together; thus showing that the septa between them were proportionally thinner. As all these comparisons, however, have to be made from internal casts only, and some additional

collections of the Ohio form show more variation in some of these characters than I had supposed existed, I should not be surprised if farther comparisons should prove the *T. Ohioensis* to be only a more robust, broader variety of *T. acuminata*. Still, I have not yet seen sufficient reasons for uniting the two forms under one name, as the specimens thus far compared do not show an unbroken series of intermediate forms.

In order to afford the student the means of making a more satisfactory comparison, the foregoing cuts of the internal casts of the ventral valves of *T. acuminata* and *T. Ohioensis* are given. That of *T. acuminata*, is from a small Canadian specimen sent by Mr. Billings. It is a little defective on one side; but as such shells are of course symmetrical, this defect has been carefully restored from the unbroken opposite side. All of our specimens of these shells being merely rough internal casts, we have not the means of illustrating the muscular impressions.*

Locality and position: Genoa, Ottawa county, Ohio. From beds referred to the Niagara group of the Upper Silurian.

GASTEROPODA.

Genus PLATYOSTOMA, Conrad, 1842.

(Jour. Acad. Nat. Sci. Philad., Vol. VIII., p. 275.)

Platyostoma Niagarensis, *var.* trigonostoma.

Plate 16, figs. 3 *a. b, c.*

Platyostoma Niagarensis, Hall, 1852; Palæont. N. Y., Vol. II., p. 287, pl. 60, figs. 1 *a* to *v;* Hall and Whitfield, List Fossils from Louisville, p. 10, dated June, 1872.
Platyostoma ? trigonostoma, Meek, 1871; Proceed. Acad. Nat. Sci. Philad., p. 169.

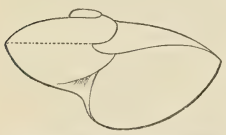
Shell strongly depressed, sub-discoidal, or lenticular, with periphery rather acutely angular; spire much depressed or scarcely rising above the inner edge of the body volution, which is more convex below than above the angle around the periphery; volutions three, very rapidly increasing in size, particularly in breadth, nearly flat, with an outward slope above; last turn large, depressed convex below, a little declining near the aperture on the inner side above; suture linear; aperture large,

* Mr. Thos. Davidson, of Brighton, England, and Prof. Wm. King, of Queen's College, Belfast, Ireland, will soon publish an elaborately illustrated paper on the family *Trimerellidæ*, made out from extensive collections of well-preserved specimens. In this paper, the muscular scars in *Trimerella* will doubtless be fully illustrated and described.

sub-trigonal, with greater breadth than height; lip extended forward on the inner side above, and thence directed very obliquely outward and backward to the marginal angle. Surface, as determined from casts, with marks of growth curving back very obliquely above and below to the angular periphery.

Height, 0.62 inch; breadth, 1.08 inches; height of aperture, 0.50 inch; breadth of do., 0.65 inch.

The specimens of this shell studied by me (without the slightest indications of accidental distortion), are so decidedly more depressed, and have the upper side of the volutions so much more flattened, and the periphery so much more angular than any of the varieties of *P. Niagarensis* illustrated by profile or lateral views among Prof. Hall's figures of that species, that I could not believe it even a strongly marked variety of the same. Since my description was published, Prof. Hall and Mr. Whitfield have regarded it as the *P. Niagarensis;* and after comparing it with a series of authentic New York specimens of that extremely variable shell, I am inclined to think it may be a variety of the same. Still, it differs, in a marked degree, in its more decidedly angular periphery, and the more flattened character of the upper side of its volutions, from any of the New York examples of *P. Niagarensis* I have seen. The annexed outline cut will illustrate its form as seen in a side view, and will also show how much it differs in outline from any of the profile figures of *P. Niagarensis* given in the Palæontology of New York, Vol. II., pl. 60; in which volume that shell is also described as being "globose."



PLATYOSTOMA NIAGARENSIS, *var.* TRIGONOSTOMA.

A profile, showing the depressed character of the spire and the angularity of the periphery, form of the aperture, etc.

Locality and position: Yellow Springs, Ohio; Niagara group of the Upper Silurian.

CEPHALOPODA.

GENUS LITUITES, Montfort, 1808.

(Conch., p. 279.)

LITUITES, ? ORTONI, Meek.

Plate 15, fig. 4.

Shell small, discoid; umbilicus comparatively large, but very shallow, the outer turn of the coil being scarcely more convex than those within; volutions three or more, slender, slightly embracing, and increasing very gradually in size, apparently scarcely wider transversely than in

their dorso-ventral diameter, evenly rounded on the sides and periphery; siphuncle unknown; septa separated on the periphery by chambers measuring less than half the dorso-ventral diameter, and generally gently arched backward on the sides; surface and outer chamber unknown.

Greatest diameter of the involuted and chambered part of the shell, 1.16 inches; dorso-ventral and transverse diameter of the outer turn, each 0.35.

As the only specimen of this species yet found does not show the outer or last chamber, and consists entirely of the chambered and involuted part, we have not the means of determining, beyond doubt, whether or not the outer or body chamber was deflected from the curve of the inner volutions. If not, of course it cannot be a true Lituite, but would most probably belong to the genus *Gyroceras*, and have to take the name *G. Ortoni*. The very slender, nearly cylindrical, and closely coiled nature of its volutions, however, are characters that seem to indicate that it belongs more properly to *Lituites* than to *Gyroceras*, in which latter group they usually increase more rapidly in size, and are generally more loosely coiled. The slender, rounded and compactly coiled nature of its volutions, gives to the shell much the general appearance of the common myriapod *Iulus*, as seen lying on one side and rolled together.

The specific name was given in honor of Prof. Edward Orton, of the Ohio Geological Survey, who discovered the only specimen of the species I have seen.

Locality and position: Niagara group, Greenville, Darke county, Ohio.

ARTICULATA.

CRUSTACEA.

Genus LEPERDITIA, Ronault, 1851.

(Bull. Soc. Geol. Fr., 2d ser., t. VIII., p. 377.)

Leperditia alta, Conrad (sp.).

Plate 17, figs. 2 *a*, *b*.

Cytherina alta (Conrad), Vanuxem, 1843; Geological Report, III. Dist. N. Y., p. 112, fig. 6.

Leperditia alta, Jones, 18—; Ann. and Mag. Nat. Hist., Vol. XVII. (2d series), p. 88, fig. —; Hall (1859), Palæont. N. Y., Vol. III., p. 373.

Carapace-valves longitudinally sub-ovate, being wider posteriorly than in front, with dorsal margin straight, the ventral forming a broad semi-

ovate curve, a little more prominent behind than in front; and the anterior and posterior margins rounded so as to connect with the dorsal border above, at very obtuse or scarcely defined angles. Left valve having its greatest convexity situated centrally with relation to the length, and considerably below the middle, where it swells out in the form of an obtuse, undefined prominence, from which the lower margin is abruptly inflected nearly or quite at right angles to the vertical plane of the valve; eye tubercle situated distinctly above the middle, and a little less than one-fourth the entire length of the valve, behind the most prominent part of the rounded front margin, sometimes accompanied by a slight furrow that curves upward and backward from its anterior side to the dorsal margin above. Surface of casts smooth, or nearly so.

Length, 0.42 inch; height, 0.26 inch; convexity (of the left valve only), 0.08 inch.

A right valve associated with the above (see fig. 2 *b*), and probably belonging to the same species, is longer in proportion to its height, and less convex near the middle of the lower side, though its lower margin is strongly inflected. It also shows scarcely any traces of an eye-tubercle in the cast.

As I have only seen internal casts of this species, I am not entirely sure that it is exactly the same as *L. alta*, though it probably is. Our figures were prepared with the intention of having them cut in lines only, and the concentric marks were merely intended to represent shading. They were afterwards added to the plate where they now appear, however, with the view of having them represented merely in outline; but the lithographer supposing the concentric lines to be surface markings, put them in so as to present a different appearance from what they would have done in a wood-cut. The figures can therefore only be relied upon as accurate outlines of the fossil, enlarged to twice the natural diameter.

Locality and position: In New York, *Leperditia alta* occurs abundantly in the subdivision known as the *Tentaculite* limestone, formerly included as a part of the Waterlime group, of the Upper Silurian. The specimens here figured are from beds referred to the Helderberg group, at Greenfield, Ohio.

Genus ILLÆNUS, Dalman, 1826.

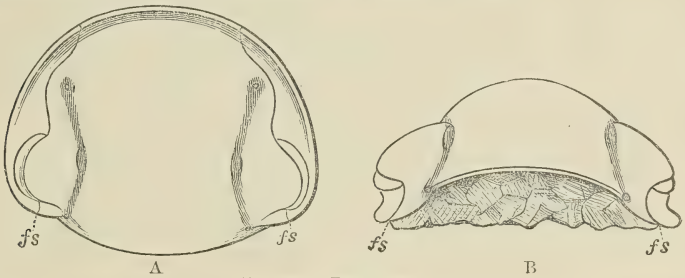
(Palæont., p. 51.)

Illænus (Bumastus) insignis, Hall?

Plate 15, figs. 5 *a*, *b*, *c*.

Illænus insignis, Hall; Advance sheets from Regents' Report, p. 27, dated Dec. 26, 1864; Regents' 20th Report (1868), p. 331, with wood-cuts, and on pl. 22, figures 13 and 14; also second edition of same, p. 419, with same cuts and lithographs.

Compare *Illænus* (*Bumastus*) *Worthenanus*, Winchell and Marcy, 1865; Enumeration of Fossils from the Niagara Limestone at Chicago, p. 105.



Illænus (Bumastus).

A—An outline of the head as seen from above, showing the form of the glabella, eyes, etc.; with the dorsal furrows terminating anteriorly and posteriorly in pits; also the facial sutures, which terminate posteriorly at the points marked *fs*.
B—A posterior view of same, showing the convexity; and the abrupt outward curve of the facial sutures behind, at the points marked *fs*.

Attaining a rather large size; general form elongate-oval, or sub-elliptic. Cephalic shield distinctly convex, or forming about one-fourth of a circle from the front to the posterior margin, transversely sub-oval in form, the widest part being behind the middle; posterior margin nearly straight, or moderately convex in outline, across between the ends of the dorsal furrows; anterior and anterior lateral margins, with a very narrow recurved rim, and a nearly regularly semicircular outline; posterior lateral margins narrowly rounded. Glabella rather strongly convex, the greatest convexity being a little behind the middle, where it rises distinctly above the eyes, and is evenly rounded over from side to side; dorsal furrows well defined in the internal cast, each starting from a minute marginal pit behind each eye-lobe, thence extending forward and inward to shallow, undefined little oval depressions nearly opposite the middle of each eye, from which they each curve outward and extend forward to and terminate in a well-defined pit near the lateral margins of the glabella, and about half way between the anterior ends of the eyes and the points where the facial sutures intersect the anterior margin; palpebral lobes rather large, larger than wide, narrowed and produced anteriorly, and moderately convex, with a more or less marked outward slope over

the eyes. Facial sutures extending forward from each eye, at first with a very slight outward curve, until they come nearly opposite, and rather close to the anterior terminal pits of the dorsal furrows, where they curve and extend obliquely inward and forward to the anterior margin, which they cut at points decidedly nearer together than the breadth across between the anterior ends of the eyes, or about equaling that between the greatest inward curves of the dorsal furrows opposite each eye; behind, these sutures start from the posterior incurved extremity of each eye, and curve very abruptly outward, so as to cut the margin almost directly behind and under the most prominent part of the same. Movable cheeks sloping off rather abruptly on each side, and each provided, in the cast, with a deep-rounded furrow around the base of each eye, and produced, attenuated, and incurved anteriorly, the widest part being opposite the anterior end of each eye. Eyes rather large, located back almost over the posterior lateral margins, strongly arched outward, or forming about one-third of a circle, very slightly oblique, their anterior ends being a little nearer together than their posterior; visual surface, as seen in the cast, very narrow in its vertical diameter, which is less than one-fourth the length, measuring around the curve.

Thorax distinctly convex, about one-third wider than long, trilobation moderately well marked in casts of the interior; mesial lobe very wide, or equaling about three times the breadth of each of the lateral, measuring over the curve of all, its greatest breadth being along the middle region, forming a broad, regular arch from side to side, so as to rise above the lateral lobes as much as the entire height of the latter; as seen from above, its ten segments present nearly straight posterior margins along most of their length, but curve rather distinctly backward at each end, as they approach the lateral lobes; lateral lobes sloping off more or less abruptly, from their inner to their outer margins; pleuræ rather wide, flattened for slipping upon each other in rolling up, and apparently obtuse at their free ends, showing a slight backward arching along the entire length of their posterior margins.

Pygidium somewhat larger than the cephalic shield, and one-sixth of its breadth wider than long, very gibbous, the greatest convexity being behind the middle, from which region it rounds down rather abruptly behind, and arches over more gradually forward, without the slightest traces of dorsal furrows; while, as seen from behind, it forms a slightly depressed or sub-semicircular arch, from side to side; general outline, as seen from above, with posterior and lateral margins forming together a deep semi-oval curve, and the anterior somewhat straightened, or gently arched forward across the central region, and curving mod-

erately backward on each side, so as to connect with the anterior lateral margins by very obtuse angles, or abruptly rounded outlines.

External surface unknown, excepting from impressions of the posterior under side of the pygidium, left in the matrix, which show this part of the surface to be marked by rather coarse concentric striæ.

Entire length, following over the convex curves of head and pygidium, 4.30 inches; do., measuring direct, with head and pygidium straightened out, about 3.80 inches; length of head (direct measurement), 1.32 inches; breadth, about 1.72 inches; length of thorax, in its natural condition, 1.05 inches; length of pygidium (direct), 1.40 inches; breadth of do., 1.70 inches.

Although I refer this form, provisionally, to Prof. Hall's species *I. insignis*, I am far from being entirely satisfied in regard to its exact identity with that form. The difficulty in making a satisfactory comparison, arises from the fact that Prof. Hall's species was founded entirely upon a separate glabella, and a detached pygidium, *supposed* (but not known) to belong to the same Trilobite. On comparing the glabella of our specimens with the figures of that of *I. insignis*, it is found to agree in most respects more closely than with that of any other form I have yet seen illustrated. It has the same convexity, nearly the same form of palpebral lobes, and the same anterior prolongation of the dorsal furrows, likewise terminating in similarly situated pits. Its facial sutures also have nearly the same direction, anteriorly at least, excepting that they are rather decidedly more convergent after passing forward beyond the terminal pits of the dorsal furrows.

This latter character makes the anterior margin of the glabella about one-fifth narrower than the distance across between the anterior terminal pits of the dorsal furrows, instead of fully equaling the same, as in the published figure *I. insignis*. Again, the outline of the posterior margin of the glabella, in the type specimen of *I. insignis*, is represented much more convex than in our specimens, thus contributing to give greater proportional length to its glabella, which, however, is also longer in front of the eyes than in the form under consideration. This straighter posterior margin of the glabella, in our specimens, also gives the eyes a position relatively farther back than in Prof. Hall's figure.* If the

*Prof. Hall's outline restoration of the movable cheeks of *I. insignis* represents them as projecting out farther laterally behind, than in the form under consideration. As this is a mere restoration, however, his figure may not be correct in that particular. It also would appear to represent the posterior termination of the facial sutures as not curving outward, as in our specimens; but this may be due to the imperfection of his specimen.

pygidium referred by Prof. Hall to *I. insignis* really belongs to the same species as the glabella figured and described by him under that name, I should think our form an entirely distinct species, since its pygidium, as will be seen by comparison, presents a strikingly different outline. In *I. insignis*, it is represented *longer than wide*, very *narrowly rounded behind*, and distinctly angular at the anterior lateral angles; while in our specimens it is *wider than long*, *broadly rounded behind*, and abruptly rounded, or only sub-angular anterio-laterally.

It seems to agree pretty nearly with a form described by Winchell and Marcy, under the name *I.* (*Bumastus*) *Worthenanus;* but as these authors have given no figure, I am at a loss to determine its relations to that form, which is thought by Prof. Hall to probably be identical with his *I. insignis*. If distinct from these, it might be called *I. Springfieldensis.*

As Prof. Hall cites Wauwatosa, Wisconsin, as one of the localities from which his typical specimens of *I. insignis* were obtained, I borrowed for comparison, from Dr. F. H. Day, of that place, a fine collection of the heads and pygidia of the form found there that is regarded as most nearly corresponding to Prof. Hall's figures of that species. In most of these specimens, however, the glabella agrees more nearly in form with that figured by Prof. Hall under the name *I. cuniculus*, being proportionally shorter, with the posterior margin less convex in outline, and the eyes more prominent and placed proportionally farther back, while the facial sutures are less sinuous, and not so converging anteriorly. They generally have the dorsal furrows, however, more or less defined, and terminating in pits, in front of the eyes, as in *I. insignis.*

If any of these specimens really belong to *I. insignis*, they would certainly seem to show that species to vary in the shape of the glabella, to such an extent that no well-defined and constant differences can be found in this part of the animal for the establishment of the two species *I. insignis* and *I. cuniculus.* However that may be, the specimens of pygidia sent by Dr. Day from the same locality and position, agree exactly with Prof. Hall's figure of a pygidium referred by him to *I. insignis.*

On comparing the glabella of the Ohio specimens under consideration with Prof. Hall's figure of the corresponding part of *I. insignis*, it will be seen to be proportionally shorter, to have its posterior margin much less convex in outline, and the facial sutures even more strongly sinuous and converging in front of the eyes, than represented in the figure of that species; with which, however, it agrees in having the dorsal furrows extending forward in the cast, and terminating in pits anteriorly. Yet in all of these characters, excepting its less convex posterior outline and pro-

portionally shorter form, it differs more decidedly from the figure of *I. cuniculus.*

If the pygidium figured by Prof. Hall as that of *I. insignis* really belongs to the same species as the glabella figured by him under that name, I should think our specimens almost certainly specifically distinct, as it is proportionally decidedly longer, and more narrowly rounded in outline, being very nearly or quite as long as wide, and longitudinally semi-elliptic; while in our form it is decidedly wider than long, and transversely sub-elliptic.

Through the kindness of Prof. Marcy and Prof. Winchell, I have also had an opportunity to compare our specimens with the form described by them under the name *Illænus Worthenanus*, and thought by Prof. Hall probably to belong to his species *I. insignis.*

Locality and position: Springfield, Ohio. Niagara group of the Upper Silurian.

FOSSILS OF THE CORNIFEROUS GROUP.

MOLLUSCA.

POLYZOA.

Genus PTILODICTYA, Lonsdale, 1839.

(Murchison's Sil. Syst., p. 130.)

Ptilodictya (Stictopora) Gilberti, Meek.

Plate 18, figs. 1 *a*, *b*, *c*.

Ptilodictya (*Stictopora*) *Gilberti*, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 7.

Corallum growing in thin, or much compressed, branching (or perhaps sometimes foliaceous) expansions; branches varying from about half a line to three lines in breadth, with a thickness of near half a line; non-poriferous margins sharp, with striæ well defined, and curving laterally and forward. Pores nearly circular, or slightly oval, and provided, in well-preserved specimens, with raised margins, ranged in about eight to ten longitudinal rows in a branch two and a half lines in breadth; those in adjacent rows regularly alternating so as to produce a quincuncial arrangement; five of them occupying a space of one line, measuring longitudinally, and about six, measuring obliquely, the space between the pores in the longitudinal direction being usually a little greater than the diameter of the pores themselves; rows of pores separated by a slender, sharply raised longitudinal line. Axis forming about one-third of the thickness of the branches, and having the transverse striæ sometimes very regular, well defined, and regularly arched.

I have not seen enough of any one specimen of this species to show whether or not its branches anastomose, but as they evidently frequently

bifurcate, and send off lateral branches, it is probable that they do. It seems to be more nearly allied to *Stictopora fenestrata* of Hall, from the Chazy limestone, in the arrangement and nearly circular form of its pores, as well as in having a raised longitudinal line between each row of pores, than to any of the known Upper Silurian species. It is a much more robust species, however, with only about the same number of rows of pores, in branches of twice the breadth of those of that species, while it shows no traces of the transverse bars mentioned in the description of *S. fenestrata*. Its flattened, non-poriferous and striated margins are also much more strongly developed. Indeed, no traces of this character of the margins are represented in the published figures, or mentioned in the description of that species.

Although I am not aware that any published notice of the occurrence of this genus in the Devonian rocks has hitherto appeared, I have little hesitation in referring this species to the group, since it seems to present all the characters assigned to the same; and I have also good reason to believe the genus represented in the Lower and Upper Carboniferous. In one respect it differs from most of the species described under *Stictopora;* that is, in having the pores a little contracted and nearly circular at the aperture. In this respect, however, it appears to agree with *S. fenestrata*, the first species described under that genus; and Prof. McCoy has shown that this character occurs in British species of *Ptilodictya* of Lonsdale, of which it is now generally admitted that *Stictopora*, Hall, is only a synonym, or, at most, founded on types only sub-generically distinct.

From the same horizon as that from which the above described species was obtained, but from a different locality (Whitehouse, Lucas county), there is in the collection a foliated specimen more than two inches in breadth and 4.70 inches long, with broken margins all around. It is split in breaking the rock so as to expose one side of the strongly wrinkled and striated axis. So far as I have been able to determine from some imperfect remaining portions of the poriferous part, its pores would seem to have the same form, size and arrangement as those of the species here described. It may, therefore, possibly belong to the same species, though I am inclined to believe it will be found to be distinct. If so, it may be called *P. (Stictopora) lichenoides.* It is represented by figure 2 of our plate 18, which shows only the wrinkled surface of a piece of the axis.

Locality and position: Sylvania, Lucas county, and Marblehead. Corniferous limestone. Mr. Gilbert.

BRACHIOPODA.

Genus RHYNCHONELLA, Fischer, 1809.

(Mem. Soc. Imp. Mosc. II.)

Rhynchonella carolina, Hall.

Plate 18, figs. 8 *a–e*.

Rhynchonella (*Stenocisma*) *carolina*, Hall, 1867; Palæont. N. Y., Vol. IV., p. 337, plate 34, figs. 14–19.

Shell attaining a medium size, nearly equivalve, moderately compressed, trigonoid-subovate in general outline, the breadth about equaling the length, with the widest part usually in front of the middle, from which point the straight posterior lateral margins converge to the beaks nearly at a right angle; anterior lateral margins rather narrowly rounded into the front, which is usually nearly regularly rounded in outline, or a little projecting at the termination of the sinus along the middle; anterior margins of the valves meeting each other at a rather acute angle, both at the termination of the mesial sinus and on each side; that of the ventral valve being only gently incurved, and but very slightly produced, along the middle.

Ventral valve usually a little less convex than the other; beak prominent, narrow, and but moderately curved; mesial sinus rather broad, shallow, and flat within, at the front, and rarely extending back a little beyond the middle; surface ornamented by from twenty-five to twenty-eight simple, distinct, sub-angular, radiating costæ, of which about five to seven occupy the mesial sinus, one of those on each side being usually smaller and less prominent than the others.

Dorsal valve scarcely one-fourth more convex than the other, its greatest convexity being near the middle; beak rather distinctly incurved; mesial fold broad, depressed, flattened, or rounded, and not strongly defined, or usually extending much behind the middle, occupied by about six to eight costæ, which, like those in the sinus of the other valve, are usually somewhat larger than any of the others, excepting one on each side, which is generally smaller and more depressed. Costæ of both valves well defined to the beaks, on good specimens. Finer surface markings unknown.

Length of a well-developed specimen, 1.04 inches; breadth, 1.02 inches; convexity, 0.65 inch.

Some of our specimens of this species are about one-third larger than either of those figured in the New York Palæontology, and have the beak of the ventral valve more prominent, and the posterior lateral slopes straighter. But they agree so nearly in all other respects, that I can scarcely doubt their identity with that shell, especially as it is said to occur at the same locality. Its most marked features are its compressed, sub-trigonal form, shallow and undefined sinus, and depressed, not strongly defined, mesial fold, with one of the plications on each side of both sinus and fold usually smaller and less prominent than the others. It is also peculiar in not having the anterior margin of the ventral valve much incurved, or produced, at the termination of the sinus, but so directed as to meet that of the other valve there, at the same rather acute angle as on each side of the sinus.

It resembles *Rhynchonella? laura*, Billings (=*Leiorhynchus multicostata*, Hall); though it is less nearly like Mr. Billings's typical specimen than like some of the varieties included under the latter name. Still it may be distinguished by its straighter posterior lateral slopes, more produced beak, more regular, *simple*, and more angular plications. It also seems to be a much thicker shell than any species of the group *Leiorhynchus* known to me.

Locality and position: Corniferous limestone, Columbus, Ohio. I am under obligations to Rev. Mr. Herzer, of Louisville, Ky., for the use of the best specimens of this species I have seen.

LAMELLIBRANCHIATA.

Genus AVICULOPECTEN, McCoy, 1851.

(Ann. Mag. Nat. Hist., Vol. VII., p. 171.)

Aviculopecten parilis, Conrad?

Plate 18, figs. 6 *a*, *b*.

Avicula parilis, Conrad, 1842; Jour. Acad. Nat. Sci., Philad., Vol. VIII., p. 239.
Aviculopecten Sanduskyensis, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 161.

Shell attaining a moderately large size, strongly compressed, oblique, very nearly equivalve; exclusive of the ears, obliquely sub-oval in outline; anterior and anterio-basal margins forming an oblique sub-semicircular curve from the anterior ear to the posterior basal margin, from which the more prominent posterior outline rounds up with a shorter curve to the posterior ear; hinge line nearly three-fourths as long as the

anterio-posterior diameter of the valves below. Beaks compressed (particularly that of the right valve) and not projecting above the hinge margin; placed distinctly in advance of the middle of the valves, and somewhat in front of the middle of the hinge margin. Ears much compressed, and rather acutely angular at their extremities; anterior one more pointed than the other, extending forward as far as the margin below, from which it is separated by a deep angular sinus, that is rather more acute in the right valve, in which this ear is a little concave on its outer surface, and defined by a linear sulcus extending obliquely from the marginal sinus to the beak. Posterior ear flattened, and somewhat longer than the other, but distinctly shorter than the prominently rounded margin below; defined by a sub-angular marginal sinus, and separated from the body of the shell, in the right valve, by its flatness and the slight swell of the rather long, straight posterior umbonal slope; while, in the left valve, there is some appearance of a slight sulcus between it and the body.

Surface ornamented by numerous unequal, slender, radiating costæ, which, on the left valve, are more sharply defined, more thread-like, and sometimes separated, near the free margins, in large specimens, by spaces two or three times their own breadth, though usually a smaller rib occupies these spaces; while, on the right valve, the costæ are all more depressed, less strongly defined, proportionally wider, and separated by narrower and more shallow furrows. Fine lines, and occasional stronger marks of growth, traverse both valves concentrically, the latter often interrupting and displacing the radiating costæ.

Anterio-posterior diameter of a specimen under medium size, 1.27 inches; height, measuring at right angles to the hinge, 1.20 inches; convexity, about 0.16 inch.

In proposing the name *Aviculopecten Sanduskyensis* for the shell here described, I remarked that, "as near as can be determined from Mr. Conrad's figure, and rather brief description of a single valve of his *Avicula parilis* (Jour. Acad. Nat. Sci., Vol. VIII., pl. 12, fig. 9), the species under consideration would seem to be somewhat nearly allied. It has nearly the same general outline and obliquity, and somewhat similar ears, though its anterior ear is proportionally shorter, and defined by an impressed line extending from the sinus up to the beak. Our shell also differs," I continued, "in being very nearly or quite equivalve, instead of having the right valve flat, and the left plano-convex."

Farther comparisons, since the publication of these remarks, have led me to believe this shell most probably only a variety of the form de-

scribed by Mr. Conrad; and I therefore now place it provisionally as a synonym under his name. I am the more strengthened in this conclusion by the fact that Hall and Whitfield, after the comparison of extensive collections from this horizon in the West, have expressed the opinion that *Aviculopecten parilis* of Conrad, will probably include *A. pectiniformis* and *A. princeps* of the same author. If the species *A. parilis* varies to such an extent as to include the other two forms mentioned, it may also include that here under consideration, though I have not the necessary collections at hand to settle the question beyond doubt.

As I know nothing of the hinge or internal characters of this shell, I am not positively sure that it has the distinguishing characteristics of *Aviculopecten*, though it probably has.

Locality and position: Sandusky, Ohio. Corniferous group of the Devonian series.

Genus LUCINA, Bruguiere, 1792.

(Encyclop. Meth. I., pl. 284.)

Lucina (Paracyclas) Ohioensis, Meek.

Plate 18, figs. 7 *a*, *b*.

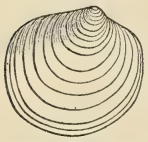
Lucina (*Paracyclas*) *Ohioensis*, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 6.
Compare *Posidonia lirata*, Conrad, 1838; see fig. 12, pl. II., 13th Regents' Report on State Cab. of N. Y.

Shell apparently not attaining a medium size, compressed, more or less nearly circular; beaks small, central, depressed nearly to the dorsal line, and contiguous; anterior margin rather abruptly compressed above, just in front of the beaks; hinge margin short and rounding into the posterior dorsal outline; surface ornamented with small, more or less regular, concentric undulations, most strongly defined on the umbones, and very fine lines of growth; posterior dorsal slopes of each valve marked by a strongly oblique sulcus, extending from the back part of the beaks to the upper part of the posterior margin, to which it imparts a slightly sinuous outline at its termination.

Length, 0.46 inch; height, 0.42 inch; convexity, 0.18 inch.

In proposing to name this as a new species, I mentioned the fact of its close relations to *Lucina lirata* (=*Posidonia lirata*, Conrad); but stated that "its peculiar posterior dorsal sulcus, which gives it so much the appearance of the recent *L. Jamaicensis*, is neither represented in Mr. Con-

rad's figure, nor mentioned in his description of *L. lirata*." At that time, I had no authentic specimens of Mr. Conrad's species at hand for comparison; but subsequently, through the politeness of Prof. Hartt, of Cornell University, I have had an opportunity to compare our specimens with good examples of *L. lirata* from the Hamilton group of New York, belonging to the Cornell museum. These specimens agree precisely with Mr. Conrad's figure and description, and show no traces whatever of the sulcus mentioned above.* In regard to the importance of this difference, opinions may differ, especially as the Ohio specimens seem to agree well in all other respects with those from New York. As I have yet seen but few of the Ohio specimens, however, I cannot assert, positively, that they may not vary in this character, though I have observed no evidence that they do; and, consequently, have not felt warranted in referring them to Mr. Conrad's species. Prof. Hall and Mr. Whitfield, however, regard them as not being specifically distinct from the New York form.



LUCINA LIRATA, Con. (sp.). A fac-simile of Mr. Conrad's original figure of his *Posidonia lirata*.

In order that the student may have the means of comparing the Ohio shell with Mr. Conrad's figure and description of *L. lirata*, I give the annexed wood-cut fac-simile of his figure, and the following copy of his diagnosis:

"Shell sub-orbicular, convexo-depressed; disc with about 18 concentric, angulated carinæ, and with concentric striæ. Length nearly one inch."

The identity of these Devonian shells with the existing genus *Lucina* may admit of some doubt, as their hinge and internal characters are not very well known. The form here under consideration, however, has even more exactly the *external* appearance of that genus than several foreign Devonian species that have generally been referred to it. Perhaps these ancient species may all be included under one distinct genus, for which the name *Paracylas*, proposed by Prof. Hall, may be retained.

Locality and position: Dublin, Franklin county, Ohio. Corniferous division of the Devonian series.

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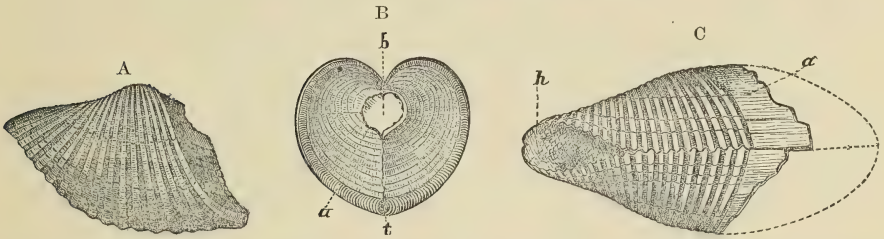
* It may be proper to remark here, that this difference cannot be due to different conditions of preservation, since both the Ohio specimens and those from New York, now before me, are alike *well-defined casts of the exterior* surface of the shell.

Genus CONOCARDIUM, Bronn, 1835?

(Leth. Geog., p. 91.)

Conocardium trigonale, Hall.



A—Side view of a medium-sized, mature specimen, being mainly an internal cast, with the umbonal alations and the anterior beak-like appendage broken away. What appears like the anterior umbonal rib in the cut, is the evenly broken off edge of the alation, and should have had the minute cross lines running more obliquely and curved in the opposite direction.

B—Anterior view of another specimen in nearly the same condition; *b* representing the broken end of the beak-like appendage; *t*, the opening of the slender sub-cylindrical canal, passing forward from the interior, between the meeting ventral edges o the alations; and *a*, on each side, the connection of the alations with the umbonal ridges.

C—A view of the under side of another specimen, retaining a portion of the alation (marked *a*), which extended at least as far forward as indicated by the dotted lines *h*, points to the posterior hiatus.

Pleurorhynchus trigonalis, Hall, 1843; Report 4th Geol. Dist. New York, p. 172, with wood-cuts, figs. 6 *a*, *b*, on p. 171; and Regents' 12th Report (1859), p. 88; (not *P. trigonalis*, Phillips, 1836=*Conocard. trigonale*, d'Orb., 1850.)*

Conocardium trigonale, Dana, 1864; Man. Geol., p. 274, fig. 457; Hall and Whitfield (excl. synon.), advance sheets extr. from Regents' Report, dated June, 1872.

Conocardium sub-trigonale, d'Orbigny, 1859; Prodr., Vol. I., p. 80.

Shell attaining a medium size, cordate-sub-trigonal, being sub-trigonal as seen from either side, and distinctly cordate in an anterior view, becoming quite convex in adult examples; anterior side abruptly truncated, with a forward slope from the beaks to the more or less angular anterior basal extremity, and flattened, or sometimes even a little concave, near the outer margins, so as to meet the lateral surfaces at about right angles, or less, along the prominent, angular, umbonal slopes, which extend to the anterior basal extremity, and are produced forward in the form of a peculiar thin alation, that is most extended below; dorsal margin behind the beaks nearly straight and horizontal, or a little declining and slightly concave in outline, with the edges of the valves incurved, while in front of the beaks it is more or less produced forward, in the

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* *Pleurohynchus trigonalis* of Phillips, has been most generally considered identical with *C. Hibernicum*, Sowerby, though some high authorities have viewed the two names as representing two distinct species. If they are distinct, of course the specific name *trigonale* could not be used for the American form, which would, in that case, have to take d'Orbigny's name, *C. sub-trigonale*.

form of a narrow (beak-like ?) extension; basal margins of the valves strongly incurved, and distinctly crenate within, nearly straight in outline, anteriorly and obliquely ascending, with a more or less convex outline posteriorly to near the hinge, below which they are widely gaping, so as to form an ovate or sub-cordate hiatus, and present a slightly sinuous outline; posterior extremity (when not broken or worn away) distinctly angular at the termination of the hinge line above; beaks moderately prominent, gibbous, and distinctly incurved nearly at right angles to the hinge, or with a very slight backward inclination. Surface ornamented by simple, regular, radiating costæ, separated by furrows of about the same size or less; costæ smaller and more crowded on the anterior flattened face of the valves than on the flanks behind the umbonal angle, and not defined on the anterior umbonal alation; crossing all of these markings, there are numerous fine, regular, crowded, concentric lines, generally much more distinct in the furrows than on the ribs between them, and more or less marked on the anterior alations; a few stronger wrinkles of growth are also usually seen at more distant intervals, especially near the lower margins of the valves, where they are more crowded together, and present a zig-zag appearance in crossing the costæ and furrows.

Length of a mature, rather short, gibbous specimen, from the anterior basal angle to the posterior extremity of the hinge, 1.32 inches; from beaks to same, 0.65 inch; height to top of umbones, 0.72 inch; convexity of the two valves, anteriorly, 0.94 inch.

This species varies more or less in general form, some examples being proportionally longer from the prominent umbonal slopes posteriorly than others which are proportionally more gibbous. In different states of preservation, the costæ and furrows between them present different appearances, being sometimes of nearly equal breadth; while in other examples, or even other parts of the same specimen, the furrows are merely linear. On well-preserved examples, the costæ are simple, but in exfoliated or worn specimens, they sometimes present a duplicated or even triplicated appearance. In some worn specimens, numerous punctures may be seen, much like those in some brachiopods, but coarser and more scattering, while others show nothing of the kind. As taken from a limestone matrix, the alations of the anterior umbonal slopes are generally broken away; and the posterior extremity is often broken or worn so as to appear more obtuse than natural, as was the case with the individual figured in Prof. Dana's Geology, as well as (apparently) that figured in Prof. Hall's report. The alations of the anterior umbonal an-

gles are most produced below, where they are sometimes an inch or more in length, in large examples; but they diminish in length (breadth, as some would understand) upward to nothing at the beaks, and consequently evidently increased with the growth of the shell; that is, they probably never increased in extent on the beaks, or at any point above the free margins, after the shell had attained any size, the additions being always made at the anterior basal angle as the valves increased in size. Broken specimens show that there was a slender, cylindrical or terete cavity extended forward in this alation along the line where its straight edges in the two valves meet below. Whether or not it terminated in an external opening, I have not been able to see, though it probably did not, as it tapers forward as the alation diminishes in thickness. It seems to have been occupied by a slender lobe or appendage of the mantle, that secreted the shelly matter forming the alation.

Notwithstanding its variations, this species may usually be readily recognized by its trigonal form, prominent and angular umbonal slopes, abruptly truncated anterior side, and (as seen in a side view) more or less angular anterior basal extremity.

Among the specimens usually referred to this species that I have seen from different localities in the West, there are two varieties, or possibly even distinct species. They appear to agree in all other characters, excepting that one is nearly always smaller, usually less gibbous, and has finer and more numerous costæ than the other. It shows about thirty costæ on each valve, behind the umbonal angle, instead of only twenty to twenty-five, as in the other variety. In Ohio, these two varieties occur at different horizons in the Corniferous group.

Locality and position: The typical specimens of this species were from the Corniferous limestone, in Erie county, New York. It also occurs in Canada, at the same horizon. I have likewise had for study a fine series of specimens from Dr. James Knapp's collection, found at probably about the same horizon at Louisville, Ky. Our Ohio specimens are from the Corniferous beds at Sandusky and Columbus. It also occurs in rocks of the same age in Indiana, and some other Western States.

Conocardium Ohioense, Meek.

Plate 18, fig. 9, and cut *a*, on page 204.

Conocardium Ohioense, Meek, 1871; Proceed Acad. Nat. Sci., Philad., p. 9.
Conocardium trigonale (part), Hall and Whitfield; Cat. Louisville Fossils, p. 12; dated June, 1872 (not of Hall, 1843).

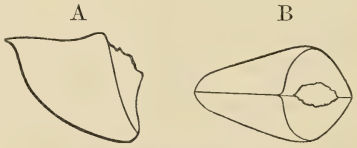
Shell rather small, longitudinally ovate-sub-trigonal, being widest and most convex anteriorly, where the valves are rather distinctly ventri-

cose; posterior side produced and abruptly contracted behind the gibbous anterior region, partly from lateral compression, and partly from the upward and backward slope of the posterior basal margin, which is slightly sinuous in outline near the extremity, and distinctly gaping, the widest part of the hiatus being above the middle; hinge line straight, or sometimes slightly declining at the posterior extremity; cardinal margins of the valves incurved; anterior side short, though not properly truncated or flattened, abruptly contracted and a little impressed in front of the umbonal convexity, apparently provided with a slender beak-like appendage above (this part broken in the specimens); beaks projecting a little above the cardinal margin, placed in advance of the middle, and incurved with scarcely any obliquity; umbonal slopes gibbous, broadly rounded and slightly inclined backward. Surface ornamented by simple, somewhat flattened, radiated costæ, about five or six of which, on the gibbous part of each valve, are larger than a few of those immediately behind them, and separated by flattened furrows nearly or quite as wide as the costæ themselves; while on the posterior contracted portion, farther back, the costæ are proportionally wider, but more depressed, and separated by merely sharply impressed hair lines, excepting near the posterior cardinal margin, where these impressed linear furrows are represented by little *raised* lines; costæ on the anterior surface more obscure, and decidedly smaller than those on the umbones; fine regular lines and a few stronger marks of growth are also seen crossing the costæ parallel to the free margins.

Length of a specimen with the anterior attenuated appendage at the end of the hinge broken away, 0.64 inch; height, 0.43 inch; convexity, 0.37 inch.

CONOCARDIUM OHIOENSE.

A—An outline side view of a specimen with the beak-like appendage broken away—natural size.
B—A dorsal view of same species, in outline, to show the rounded ventricose character of the umbonal region, and the constriction behind the same.



CONOCARDIUM TRIGONALE.

A—An outline side view of a young specimen, being mainly an internal cast with the alation and beak-like appendage broken away—the oblique line representing the angular umbonal slope. Compare with
B—Dorsal view of same. Compare with.

This form is thought by Prof. Hall and Mr. Whitfield (see Catalogue of Fossils found at Louisville) not to be distinct from *C. trigonale*. To me, however, it seems to be readily distinguishable. It is not only always smaller, but differs materially in form, from the young of *C. trigonale* of its own size, and still more decidedly from the adult of the

same. These differences will be more readily understood by reference to the annexed outline cuts than from our figure on plate 18, which was drawn from a specimen that is a little defective at the anterior basal margin, though its marks of growth clearly show it to have the same form. From these cuts it will be seen that the shell under consideration, instead of having its anterior margin, below the extension at the anterior end of the hinge, sloping obliquely *forward*, or descending more or less nearly vertically to an anterior basal angle, has it sloping obliquely *backward* and rounding regularly into the base, without forming with the latter the slightest traces of an angular outline. I am aware that this anterior basal angle in *C. trigonale* is less produced and more blunted in young than old specimens, especially when the alation is broken away; but I have never seen a specimen that I could refer to the young of that species, with the outline of the anterior basal margin approaching that seen in the annexed cut, A. Nor do the marks of growth on well-developed specimens of that species indicate that they ever presented such an outline at any age.* An equally important difference is also observable in the umbonal slopes, which, instead of being *distinctly angular* from the beaks to the anterior basal margin, as they are even in internal casts of *C. trigonale*, are *broadly* and *regularly rounded* throughout their entire length. I cannot see how this difference can be due to differences of age and size, because it must be evident that, after the beaks were formed, and the shell had grown to any given size, additional angularity could not have been imparted to the umbonal slopes near the beaks by any farther growth of the shell; nor even any greater extension there to the alation, the additions to which were always made at the anterior basal angles of the valves, at which points the increase to the alation doubtless continued as long as the shell continued to grow. This angularity of the umbonal slopes is not only strongly defined in young specimens of *C. trigonale*, such as that represented by our outline cut, figs. A and B, but it can be traced, clearly and strongly defined, even to the points of the beaks, on all of the adult shells or internal casts of that species I have seen.

In addition to this, there is a decided constriction just behind the swell of the umbonal region in *C. Ohioense*, best seen in a dorsal view (see cut B), of which I have seen no traces in well-developed specimens of *C. trigonale*, where it would at least occur near the beaks, if it had existed in the young shell. Another difference may also be seen in the size of the costæ, or the breadth of the furrows between them, on the

* When these marks are well defined, it is always easy to determine from their curves on the umbonal region of the adult the exact outline of the young shell.

gibbous part of the umbonal region, where they are proportionally larger in *C. Ohioense* than on the corresponding parts of the umbones in the young, or mature, well-defined examples of *C. trigonale*, both of which likewise have the anterior faces of the valves decidedly more flattened than in our shell. From the roundness of its umbonal slopes, and its broadly rounded anterior basal margin, it also seems very improbable that *C. Ohioense* ever had any umbonal alation, though it possibly may have had.

Among collections from several western localities, there occur specimens of a small shell usually considered the young, or a variety, of *C. trigonale*, that agree with *C. Ohioense* in the ventricose character of the anterior region, and the distinct constriction behind the same, but differ in having the umbonal slopes slightly angular, and the anterior ventral margin a little angular and somewhat prominent in outline, instead of sloping and rounding regularly backward into the base. The fact, however, that we do find other specimens of equally small size associated with adult, well-developed *C. trigonale*, and agreeing well with that shell in the distinctly carinated character of the umbonal slopes, the produced and angular outline of the anterior basal margin, and the absence of any constriction behind the flattened backward converging (not ventricose) umbonal region, seems to render it very improbable that the other small specimens more nearly approaching the form of *C. Ohioense* are really also young individuals of *C. trigonale*. Whether or not these latter may shade by intermediate forms into *C. Ohioense*, I am not able to decide, without more specimens for comparison, but it is not improbable that such may be the case. I cannot conceive, however, how the young of *C. trigonale* could ever have had such a ventricose umbonal region, with the decided constriction seen behind it, without some indications of these peculiarities being observable near the beaks of the numerous adult specimens of that species found.

Locality and position: Corniferous limestone of the Devonian, near Columbus, Ohio.

Genus SOLEMYA, Lamarck, 1818.

(Hist. Vol. V., p. 488.)

Solemya (Janeia) vetusta, Meek.

Plate 18, fig. 4.

Solemya (Janeia) vetusta, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 10.

Shell of medium size, transversely sub-oblong, or narrow sub-elliptic, the length being a little less than twice and a half the height; valves rather convex; anterior or longer side regularly rounded; posterior ex-

tremity more narrowly rounded; basal margin nearly or quite straight along the central region, but rounding up at the extremities, the curve being more gradual behind; beaks depressed to a level with the dorsal margin, and placed somewhat behind the middle; dorsal margin a little convex and nearly horizontal in front of the beaks, but rounding regularly into the anterior outline, and behind the beaks, slightly depressed below the horizon of the latter, though without sloping much posteriorly. Surface apparently smooth; interior showing distinct, radiating striæ below the middle of the valves, excepting near the extremities. Posterior muscular impression rather narrow, sub-oval, oblique, placed near the margin, and well defined by a slight oblique ridge along its anterio-inferior margin; anterior do., larger and faintly marked.

Length, 1.22 inches; height, 0.50 inch; convexity, 0.32 inch.

This is another type very unexpectedly found among the Corniferous specimens. So far as I am aware, no example of this group has ever before been obtained from any horizon below the Mountain limestone. Whether we regard the Carboniferous and Permian forms usually referred to *Solemya* as really belonging to that genus, or as constituting a distinct group (for which Prof. King proposed the name *Janeia*), there can be no question whatever that the shell here described belongs to the genus that includes these Carboniferous and Permian species. Specifically, it is perhaps more nearly related to *S. biarmica* of the European Permian rocks than it is to *S. Puzosiana*, de Kon., or to *P. primæva*, Phillips, from the Carboniferous. Indeed, it might even be referred to *S. biarmica* with more propriety than a Kansas Coal-measure species that has been so referred by Prof. Geinitz. Compared with the figures of the original Russian example of *S. biarmica*, figured in the Palæont. of Russia and the Ural Mountains, pl. XIX., fig. 4 *a* and 4 *b*, our shell is seen to be proportionally somewhat more depressed and longer, with the beaks a little less prominent, and farther removed from the shorter or posterior extremity. Its posterior dorsal slope, even in the internal cast, is also less oblique. In this latter character it is even less like the English and German Permian forms referred to *S. biarmica*.

I have elsewhere (Proceed. Acad. Nat. Sci., April, 1870, p. 44) expressed the opinion that these Palæozoic shells usually referred to *Solemya*, may yet have to be separated from that genus, and ranged under Prof. King's name *Janeia*, notwithstanding the fact that he subsequently abandoned his genus, under the impression that it is not distinct from *Solemya*. I still think it probable that this may have to be done.

Locality and position: Dublin, Franklin county, Ohio. Corniferous group of the Devonian.

Genus CLINOPISTHA, Meek and Worthen, 1870.

(Proceed. Acad. Nat. Sci., Philad., p. 43.)

Clinopistha antiqua, Meek.

Plate 18, figs. 5 *a*, *b*.

Clinopistha antiqua, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 11.

Shell very thin, transversely sub-oval, gibbous, with flanks along the middle, near the lower margin, somewhat flattened or slightly concave; more than half as high as long; anterior or longer side regularly rounded in outline; posterior sloping above from the beaks to the narrowly rounded extremity, which is most prominent below the middle; basal margin straightened or broadly sinuous along the central region, and rather abruptly rounded up at the extremities; beaks depressed nearly or quite to the dorsal outline, and placed about half way between the middle and the posterior extremity; dorsal outline nearly horizontal and parallel to the base, in front of the beaks, but rounding regularly into the anterior margin. Surface merely showing moderately distinct lines of growth, with some obscure traces of radiating striæ, where a little worn near the base; these last mentioned markings being more distinct on the internal cast.

Length, 0.22 inch; height, 0.51 inch; convexity, 0.39 inch.

I have been much surprised to find among the collections from the Corniferous limestone a shell agreeing so exactly as this, in all its known characters, not evidently merely specific, with the type of the genus *Clinopistha*, which group I had previously supposed to be confined to the Coal-measures. It has the same short, gibbous form, thinness of substance, posterior position of the beaks and ligament, surface markings, and even the same obscure, internal, radiating striæ. Indeed, if it were not for its rather more narrowly rounded, and more protuberant, instead of slightly truncated, posterior or shorter and somewhat less gibbous beaks, and faintly sinuous base and flanks, it would scarcely be possible to distinguish it from the Coal-measure form, by any external character, excepting the white chalky texture of the shell, which is merely due to its state of preservation. The valves are a little displaced in the only good specimen I have seen, but the beaks certainly give some evidence of being slightly unequal—that is, of the left one lapping slightly upon the other, as in the typical species from the Coal-measures.

Locality and position: Same as last.

Genus SANGUINOLITES, McCoy, 1844.

(Synop. Carb. Foss., Ireland, p. 47.)

Sanguinolites? Sanduskyensis, Meek.

Plate 18, fig. 3.

Sanguinolites? Sanduskyensis, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 12.

Shell approaching a longitudinal-oblong or trapezoidal outline, moderately convex, a little more than twice as long as high, and slightly narrower anteriorly than behind; cardinal margin straight, equaling about three-fifths the entire length; basal margin nearly straight, or a little sinuous toward the front, and sub-parallel to the hinge, or slightly ascending anteriorly along its entire length, and rounding up a little more gradually into the front than behind; posterior extremity compressed, obliquely truncated above, and rather narrowly rounded to the base below; anterior side very short, sloping rather abruptly from the beaks above, and narrowly rounded at the middle; beaks depressed nearly or quite to the hinge line, compressed, and placed near the middle of the anterior third; posterior umbonal slopes not angular, or even prominently rounded. Surface only showing few irregular furrows and slight undulations of growth, most distinct below the middle of the valves.

Length, 2.70 inches; height at the posterior end of the hinge, 1.20 inches; do. under the umbones, 1.04 inches; convexity, about 0.52 inch.

I know nothing of the hinge of this shell, and merely refer it to the genus *Sanguinolites* provisionally. Indeed, until palæontologists can agree in regard to which one of the types that were originally referred to that genus is to be regarded as the typical form of the same, and something can be known in regard to the hinge and internal characters of those shells, it seems to me almost impossible to know what *Sanguinolites* is. I do not agree with those, however, who would make *Allorisma* of King a synonym of Prof. McCoy's genus, though some of the species included by him may belong to *Allorisma*.

Locality and position: Same as foregoing.

GASTEROPODA.

Genus PLATYCERAS, Conrad, 1842.

(Jour. Acad. Nat. Sci., Philad., Vol. VIII., p. 275.)

Platyceras multispinosum, Meek.

Plate 20, figs. 7 *a*, *b*.

Platyceras multispinosum, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 17.

Shell attaining a large size, comparatively thin, depressed sub-ovate, and very oblique; apex free, stout, obliquely coiled, so as to make about one turn, beyond which the body part expands very rapidly to the aperture, making less than half of another volution; aperture proportionally very large and nearly circular; lip not sinuous or undulated, but sometimes slightly and broadly retreating behind; surface without plications or costæ, but thickly covered by numerous slender tubular spines, which leave small, depressed, smooth, undefined tubercles on the internal cast.

Length, measuring direct from the most prominent part of the spire to the anterior margin of the aperture, 3.33 inches; height to the most elevated part of the dorsal surface, when the shell is placed with its aperture downward, 1.44 inches; length and breadth of aperture, each about 2.90 inches.

This fine species differs from *P. dumosum*, Conrad, not only in its much larger size, more oblique, depressed, and more rapidly expanding form, but in having much more numerous spines. The largest specimens of that species are said to have more than one hundred spines, while that under consideration must have had more than two hundred. It likewise differs in not having its lip waved or undulated, as in Mr. Conrad's species.

It is probably more nearly related to *P. echinatum*, Hall, from the Hamilton group. No figures of that species have yet been published, but judging from the description, our shell is not only very much larger (that species being described as from one to one and a quarter inches in length, with an aperture one inch in diameter), but wants the sinuous peristome mentioned in the description of *P. echinatum*. The term "strong nodes" would also not apply to the numerous small, obscure

elevations marking the positions of the spines on internal casts of our species.

None of our specimens show the entire length of the spines, but judging from the fact that their broken ends, at a distance of 0.42 inch from their bases, only measure 0.08 inch in diameter, they would seem to have been probably shorter and more slender, as well as much more numerous, than those of *P. dumosum*. Although these spines are as completely tubular as those of the genus *Productus*, their internal cavity does not seem to have communicated with the interior of the shell, with probably the exception of those near the lip; for if that had been the case, the smoothly rounded, obscure tubercles seen on the internal cast would have shown the broken bases of the casts of the internal cavities of the spines.

Prof. Hall and Mr. Whitfield, in their list of the fossils found at Louisville, Kentucky, issued after the publication of the foregoing description and remarks, have placed this species as a synonym of *Platyceras dumosum*, Conrad. In view of the well-known variability of the species of this genus, I am willing to admit that it *may* possibly be an extreme variety of Mr. Conrad's species; though I have not yet seen the intermediate forms that would connect it with the typical examples of that shell, or with any others that could, with certainty, be identified with the same. I can only say that it differs, in a very marked degree, in size, form, and nearly all of the other characters usually regarded as specific in the genus, from the figure given by Prof. Hall in the Regents' 12th Annual Report, p. 19, as an illustration of *P. dumosum*.* It is also certainly greatly larger than the maximum size of that species, as given by Prof. Hall in the 15th Report of the Regents, page 37, where *P. dumosum* is said to attain, "in its full size, a length of two and a half inches;" while specimens of the form under consideration, now before me, measure full *four inches* in length. Whatever may be thought of these differences, I think palæontologists will generally admit that the shell under consideration is, at least, as distinct from *P. dumosum* as several forms figured by Prof. Hall in the third volume of the Palæontology of New York, under different specific names, are distinct from each other.

Locality and position: Columbus, Ohio. Corniferous group of Devonian series.

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* Mr. Conrad gave no figure of his type, and his description, although sufficient to distinguish it from any of the other species then known to him, is so brief that it would apply almost equally well to any one of the several other spiniferous species now known.

Platyceras dumosum, *var.* attenuatum.

Plate 20, figs. 2 *a*, *b*.

? Platyceras dumosum, Conrad, 1840; Ann. Rep. Palæont. N. Y., p. 205; Hall (1859), 13th Regents' Report, p. 19.

Platyceras attenuatum, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 75.

Shell attaining a moderate size, very slender and elongated. Body part more or less arched above, a little compressed behind, sub-angular on the right side, rounded over the dorsal or anterior slope, and gradually tapering backward to the small free apex, which is composed of one to one and a half contiguous volutions, and twisted to the right of the longitudinal axis of the body.* Aperture irregularly oval, or sub-triangular, and comparatively small or little expanded; lip most produced on the right anterior side, and sometimes a little retreating behind, with, at one or two other points, smaller undulations of its margin around the front. Surface of cast without longitudinal plications, folds or undulations, but showing, on internal casts, over the dorsal and anterior slope, numerous small tubercles, that evidently mark the positions of spines on the exterior. Surface markings of the shell itself unknown.

Length of the larger specimen, measuring direct from most prominent part at the curve of the spine to that of the anterior margin of the aperture, 2.10 inches; do., measuring from the apex over the dorsal curve to the same, about 3.70 inches; greatest breadth of aperture, 1.35 inches.

This shell seems to differ from all of the described spiniferous species with which I am acquainted, in being more slender, more elongated, and in having the small apex twisted nearly at right angles to the axis of the body part. These characters appear to distinguish it readily from the *typical form* of *P. dumosum*, Conr.; while, from the variety of that species that has has been described under the name *rarispinum*, it differs in never having its body even "moderately ventricose," nor in any case in contact with the apical coils, as well as in having more numerous spines, if we can judge from the number of tubercles, of which about fifty may be counted on the specimen from which the foregoing description was made out. I place it, with considerable doubt, as a variety of *P. dumosum*.

* I describe such forms, for convenience, as if placed with the aperture downward and apex directed backward toward the observer.

In general form, it resembles the more slender individuals of the non-spiniferous species *P. reflexum*, from the Oriskany Sandstone, but its body part is much straighter, while it is never so large and ventricose as in some varieties of that species.

Locality and position: Columbus, Ohio. Corniferous group.

Genus CYCLONEMA, Hall, 1852.

(Palæont. N. Y., Vol. II., p. 89.)

Cyclonema crenulata, Meek.

Plate 19, figs. 2 *a, b, c, d.*

Cyclonema crenulata, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 79.

Shell turbinate-subtrochiform, thin; spire depressed conical; volutions four, increasing rather rapidly in size, those of the spire convex, but not rounded; last one large, convex on the upper slope to the periphery, which is rather narrowly rounded; suture well defined between the upper volutions, and somewhat canaliculate farther down; aperture ovate. Surface ornamented by sharply elevated, revolving lines or small ridges, which are beautifully and minutely crenated by the crossing of the fine, very oblique lines of growth. Of these revolving lines, from sixteen to eighteen may be counted on the body volution, and six on the next above, while those farther up appear to be quite smooth.

Length, 0.34 inch; breadth, 0.32 inch.

This species seems to be somewhat related to *C. multilira*, Hall (Fifteenth Report of Regents, p. 48, pl. 5, fig. 17), but has a decidedly more depressed form, with the volutions of its spire merely convex, instead of rounded, and its body volution narrowly, instead of regularly, rounded. It also has more revolving lines, which likewise show a delicate crenate character not represented in the figure nor mentioned in the description of *C. multilira.*

In general appearance, our shell more nearly resembles Mr. Conrad's original figure of his *C. bilix* (Jour. Acad. Nat. Sci., Vol. VIII., pl. XVI., fig. 10), but it is less oblique, with more convex volutions, and more numerous revolving lines.

Locality and position: Same as last.

Genus NATICOPSIS, McCoy, 1844.

(Synop. Carb. Foss. Ireland, p. 33.)

Naticopsis? (Isonema) humilis, Meek.

Plate 19, figs. 1 *a*, *b*, *c*.

Isonema humilis, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., page 79.
? Naticopsis lævis, Hall and Whitfield, 1872; Descrip. New. Sp. Foss., pl. 12, figs. 3, 4 and 5 (not *N. levis*, Meek, 1871).

Shell large and robust, depressed sub-turbinate, about one-fourth to near one-third wider than high; spire much depressed; volutions four, increasing rather rapidly in size, the exposed part of those of the spire gently convex; last one large, and regularly rounded, or sometimes very obtusely sub-angular around the middle of the outer side; suture well defined, without being properly channeled; aperture nearly circular a little within, but more or less angular above, at the immediate edge of the lip, where it is more oval in outline; outer lip thin, and in mature specimens slightly dilated; inner lip thickened, very distinctly flattened, and slightly spread over the imperforate umbilical region, as well as a little thickened near the top of the aperture. Surface ornamented with oblique, slightly arched lines of growth, which, on the first and second turns of the spire, are rather coarse, well defined, and present the characteristic regularity of size and arrangement, but soon become, on the succeeding turns, much finer and more crowded, as well as occasionally interrupted by irregular, stronger furrows and wrinkles of growth.

Height of a medium-sized specimen, 1.10 inches; breadth, 1.56 inches; height of aperture, measuring at the margin of the lip, to the top of the angle above, 0.95 inch; breadth about 0.87 inch.

At one time I suspected that this might possibly be the same species as *Isonema depressa*, M. and W.; that is, that it might be the adult, and *I. depressa* the young of the same species. I hardly think now, however, that this is so. It certainly shows only the same number of volutions, in individuals attaining nine or ten times the bulk of that form, and differs in being less depressed, and having more rounded and more ventricose volutions, as well as a less strongly and regularly striated surface on the upper side of the volutions. There can be no doubt, however, that it belongs to the same group.

It must have been from a rather hasty reading of my description of *Naticopsis levis*, that Hall and Whitfield referred to that species, in their list of fossils found at Louisville, the shell represented by the annexed cut, which I believe to be identical with the species here described. By reference to my description of *N. levis*, it will be seen that I distinctly described it as "sub-ovate in general outline," and gave the length of the largest specimen as 0.60 inch, with a breadth of only 0.48 inch; or, in other words, with the breadth only four-fifths the length; while the shell figured by them as *N. lævis* is decidedly *wider* than *high*, and so completely different in nearly all other respects as to leave room for doubts whether it really belongs to the same genus. Their specimen was much more nearly complete than any of those I have seen of the form under consideration, as it shows the lip entire, the whole of the broad flattened columella, and the exact outline of the aperture—in short, the whole shell; consequently, I have added an outline of their figure. Whether *exactly* identical, specifically, with the form here under consideration or not, it, beyond all question, belongs to the same group. Since seeing their figure of a specimen showing so clearly all of the characters of *Isonema*, I am led to think that group more nearly allied to *Naticopsis* than I had supposed. Still, I doubt very much whether such depressed species, differing so materially in physiognomy from the typical Carboniferous forms on which *Naticopsis* was founded, ought to be included under the same genus. If so, however, they certainly should be placed as a distinct sub-genus, which would require the name of the species *depressa* to be written *Naticopsis* (*Isonema*) *depressa*.

NATICOPSIS (ISONEMA) HUMILIS.

An outline of a figure, apparently of this species, given by Hall and Whitfield, showing the aperture and lip more completely than any of our specimens. (See Descr. New. Sp. Devonian Foss. from Iowa, pl. 12, fig. 3.)

Locality and position: Same as foregoing.

NATICOPSIS LEVIS, Meek.

Plate 19, figs. 4 *a*, *b*.

Naticopsis levis, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 76 (not *N. lævis*, Hall and Whitfield, 1872); Descrip. New. Sp. Fossils from Devonian rocks of Iowa, pl. 12, figs. 3, 4 and 5.

Shell apparently attaining a medium size, sub-ovate in general form, at maturity, but proportionally shorter in the young; spire moderately prominent; volutions four to four and a half, convex, increasing rather

rapidly in size; last one large, or forming near nine-tenths of the entire bulk of the shell, rounded on the sides, and a little extended below; suture well defined; aperture ovate, being regularly rounded below, and more or less angular above; columella arcuate and distinctly flattened, or a little concave below the non-perforate umbilical region, above which the inner lip is thickened. Surface only showing obscure lines of growth.

Length of the largest specimen seen, 0.60 inch; breadth, 0.48 inch; height of aperture, 0.38 inch; breadth of do., 0.27 inch.

So far as I am at present informed, this is the first Devonian species, beyond doubt known to belong to this genus, that has yet been described in this country, though it is certainly represented in rocks of that age in Europe.* Our species is even more closely allied to the typical Carboniferous forms of the genus than it is to the European Devonian species, such as *Naticopsis subcostata* and *N. margaritifera* [=*Natica subcostata* and *N. margaritifera*, *d'Archiac* and *de Verneuil*].

It is an interesting fact that the above-mentioned European Devonian species represent both of the sub-genera found in our Coal-measures; the first belonging to the sub-genus *Trochydornia*, and the other to the typical section of the genus.

Locality and position: Dublin, Franklin county, Ohio. Corniferous group of the Devonian.

Naticopsis æquistriata, Meek.

Naticopsis æquistriata.

a View of aperture, lip, etc., magnified about 3 diameters.

b An opposite view of same; showing the strongly curved striæ a little too fine to correspond with the size of the magnified figure.

Shell sub-globose; spire much depressed; volutions four, increasing rapidly in size, those of the spire convex, last one large and ventricose; suture well defined; aperture ovate; outer lip thin, extended forward and very oblique above, and broadly retreating or sinuous below the middle; columella narrow, arcuate, imperforate, and showing some appearance of being a little furrowed below, as if for the reception of the edge of an operculum; inner lip apparently not thickened above. Surface ornamented by fine, very regu-

* It is probable that several of the so-called Naticas of the European Silurian rocks also belong to this genus, as may be the case with some of the American Silurian species referred to *Holopea* and other genera, from the study of mere casts.

larly and closely arranged striæ of growth, which pass very obliquely backward and downward on the upper and outer side of the body volution, and then curve gracefully forward again below, so as to conform to the broad sinuosity of the outer lip.

Height, 0.17 inch; breadth, 0.18 inch.

This little shell will be at once distinguished from the young of the last, of corresponding size, with which it agrees very nearly in form, by its beautiful, very regular, well-defined, and gracefully curved striæ, as well as by its narrower columella and thin inner lip. The latter characters lead me to doubt whether it is not more properly a *Platyostoma*.

Locality and position: Same as last.

Genus ORTHONEMA, Meek and Worthen, 1861.

(Proceed. Acad. Nat. Sci., Philad., p. 146.)

Orthonema Newberryi, Meek.

Plate 20, figs. 3 *a*, *b*.

Orthonema Newberryi, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 81.

Shell turreted, elongate-conical; volutions eight or nine in adult examples, compressed-convex, with a more outward slope than the general slant of the spire, the most convex part being near the lower side of each, a little above the suture; first one or two very small and depressed, and the next one or two more rapidly increasing in size than those below, thus giving a proportionally shorter and more conical appearance to young than adult specimens; suture well defined in consequence of the prominence of the lower part of each turn just above. Surface ornamented by three very slender, raised, revolving lines, one of which is placed a little below the suture, and the other two below the middle of the turns of the spire, and on the middle of the last volution; of these revolving lines, the upper two are broken up into minute, regularly arranged, projecting points, while the other is usually continuous; lines of growth minute, sharply defined, and very regularly and closely arranged, passing vertically and very nearly or quite straight across the volutions. Aperture unknown.

Length, 0.63 inch; breadth, 0.22 inch.

The general appearance of this very neat little shell, with its three slender revolving lines, two passing around the middle of its body volu-

tion and below the middle of those of the spire, at once recall to mind the genus *Murchisonia*. A moment's examination under a magnifier, however, shows that the sharply defined lines of growth pass straight across the volutions, without making the slightest flexure indicating a sinus in the lip, such as we see in *Murchisonia* and *Pleurotomaria*. It is a more slender shell than the type of the genus (*O. Salteri*, M. and W., from the Coal-measures), and has a much deeper suture, and a less angular body volution, with other differences in the details of its markings. Although nothing is known of the nature of its aperture and columella, it agrees so exactly in all its other generic characters with the genus *Orthonema*, that I have no hesitation in referring it to that genus. It is certainly not a *Murchisonia*, and differs radically in its ornamentation from *Isonema*, or any of the other palæozoic types to which the more or less similar univalves of the older rocks are usually referred.

Locality and position: Otsego, Wood county, Ohio, from the Corniferous group just above the Glass Sand. Mr. Gilbert.

Genus TROCHONEMA, Salter, 1859.

(Canada Org. Remains, Dec. 7, p. 24.)

Trochonema tricarinata, Meek.

Plate 19, figs. 4 *a*, *b*.

Trochonema tricarinata, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 82.

Shell turbinate, thin, a little wider than high; spire depressed. Volutions about five, strongly shouldered, or nearly rectangular above, the upper surface being flat, or a little concave, and extended out almost horizontally to the rectangular and carinate shoulder; below this the outer side is nearly vertically flattened to a second carina, passing around near the middle of the body whorl, exactly coincident with the suture between that and the succeeding turn, so as not to be exposed on the spire; below this second carina the under side of the body volution is flattened with a strong inward slope to a third well-defined carina, passing around the middle of the under side, and forming the margin of the umbilicus. Aperture oval-sub-pentagonal, being a little higher than wide, and somewhat angular above, at the connection of its outer lip with the return of the spire, and at the termination of each of the three revolving carina, as well as very obscurely so a little below the middle of the inner side; inner lip thin below its connection with the carina passing around the umbilicus, at which point it is very slightly thick-

ened, while above this it seems to be nearly or quite obsolete. Umbilicus rather wide, but shallow, or very rapidly contracting within. Suture well defined, without being in the slightest degree furrowed. Surface only showing very fine lines of growth, which, on the upper flattened space of the volutions, pass obliquely outward and backward, with a very slight curve, from the suture to the upper angle or shoulder, below which they pass nearly straight down the outer flattened area to the second carina, which is as far as they can be traced in the specimen studied.

Height, 0.81 inch; breadth, 0.90 inch; height of aperture, 0.54 inch; breadth of do., 0.46 inch.

This rather neat shell seems to agree exactly in all of its generic characters with the type of Mr. Salter's genus *Trochonema* (*T. umbilicata*, Hall, sp.), excepting in not even showing any tendency to have its body volution become free at the aperture, nor apparently its peritreme continuous. The first of these characters, however, seems not to be always constant in the typical species of *Trochonema;* but the fact that it *does generally* occur in the same is worthy of note; while the apparent absence of a continuous peritreme in the shell here under consideration would certainly seem to be one of more than specific importance. If so, I would suggest for it, at least as a sub-generic designation, the name *Trochonemopsis.*

Specifically, this shell will be readily distinguished from *T. umbilicata*, which it most nearly resembles, not only by its more depressed form, closely contiguous body volution, obsolete inner lip above the middle of the aperture, and more shallow umbilicus, but also by not having its suture channeled and bordered below by a fourth carina around the upper margin of each volution, as in that species.

Locality and position: Marblehead, Ohio. Corniferous group.

Note.—In the same matrix with the above-described shell, I have been surprised to notice numerous minute bodies that I can scarcely doubt are really the fruits of the fresh-water genus *Chara.* At any rate, they certainly seem to present all the external characters of the same. These little bodies are globose, about 0.05 of an inch in diameter, and each ornamented by nine strongly defined and very regularly disposed spiral ridges, which start on one side around a minute pit, and pass with perfect regularity spirally, so as to converge to an exactly opposite point on the other side, making each about one spiral turn in passing from side to side. If really the seeds of this fresh-water genus of plants, they must have been carried into the sea by streams, and deposited where we now find them, along with numerous marine shells.

Genus EUOMPHALUS, Sowerby, 1814.

(Man. Conch. I., p. 97.)

Euomphalus Decewi, Billings.

Plate 19, figs. 3 *a*, *b;* and plate 20, fig. 1.

Euomphalus Decewi, Billings, 1861; Canadian Journal (July), p. 358, with wood-cuts; and Devonian Fossils of Canada West, p. 94, figs. 131 and 132.
Euomphalus Conradi, Hall, 1861; 14th Regents' Report (Aug.), page 107.

Shell attaining a large size, discoid in form, the upper side being moderately concave, or nearly or quite flat, and the lower broadly and deeply concave; periphery flattened-convex, and nearly vertical to the plane of the shell, or somewhat oblique. Volutions about three, irregularly sub-quadrangular, increasing regularly and gradually in size from the apex, and coiled more or less nearly (but never exactly) in the same plane, obtusely angular around the upper outer side, and thence flattened, with a more or less inward slope above, to the inner side; lower side of volutions prominent and obtusely angular at its connection with the periphery, from which point it slopes strongly inward, usually with a concave face, into the large umbilicus; aperture, like the section of the volutions, irregularly quadrangular, the inner side being much narrower, and the oblique lower side wider, than any of the others. Surface ornamented by distinct lines of growth, and sometimes, on the upper and outer sides of the volutions, by little regular ridges, both of which curve strongly backward to the angle around at the meeting of the upper and outer sides, where they make a short backward arch in crossing a slightly concave, undefined band, somewhat like that seen on *Pleurotomaria;* thus indicating a wide, deep notch in the lip at the termination of the upper angle of the volutions. A similar but less strongly defined backward curve of these markings also occurs on the outer surface of the whorls, at the lower angle.

Greatest transverse diameter of a large specimen, about 4.30 inches; height of same near the aperture, 1.66 inches.

I have had no opportunity to compare this Ohio shell with either Canadian or New York specimens of Mr. Billings's species, but it agrees so nearly in size and form with the characters of that shell, as defined by Mr. Billings and Prof. Hall, that I can scarcely doubt its identity with the same. There are, however, a few characters presented by our specimens that are not mentioned in either of the descriptions alluded to above. These are the tendency of the marks of growth to assume the

appearance of little ridges and furrows on the upper and outer surfaces of the whorls; and the presence of a slightly impressed pleurotomoid band around the upper angle of the same. Of course, if these do not exist in *P. Decewi*, our shell would belong to a distinct species at least, or possibly even have to be referred to a different group. It is probable, however, that the surface markings are variable, and that the band-like depression may have been accidentally obscured in the specimens of *E. Decewi* hitherto found.

Locality and position: The typical specimens of *E. Decewi* were found in the county of Haldinand, Canada West; and those for which Prof. Hall proposed the name *E. Conradi* came from various localities in Central and Western New York. Our fig. 1, plate 20, represents a specimen from Kelley's Island, Lake Erie, and the larger one on plate 19 was taken from a bowlder found in Defiance county, Ohio, and belongs to James Ralston, Esq., of Defiance, Ohio. Its horizon seems to be always in the Corniferous limestone of the Devonian.

Genus XENOPHORA, Fischer, 1806.

(Museum Demidovianum, p. 213.)

Xenophora? (Pseudophorus) antiqua, Meek.

Plate 17, figs. 1 *a*, *b*, *c*, *d*, *e*.*

Trochita antiqua, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 82.

Shell strongly depressed-sub-trochiform, about three times as wide as high; under side flattened, and provided with a broad, shallow, eccentric umbilical impression; volutions two and a half to three, a little convex, with a gentle outward slope above, and an acutely angular periphery at the connection of the upper slope of the whorls and the base; suture rather obscure; aperture transversely rhombic, nearly three times as wide as high, with acutely angular outer and inner extremities; upper side of lip very oblique, and extended far forward beyond that below, which latter seems to be nearly straight. Surface of upper side ornamented by rather distinct lines, or small ridges of growth, which cross the volutions very obliquely, with strong backward curves, as they approach the periphery, parallel to the margin of the lip.

Breadth, 2.12 inches; height, about 0.66 inch.

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* It was by mistake that this species was figured on this plate as if from the Waterlime horizon.

The specimens of this shell yet found are very imperfect, but its form and general appearance are so peculiar that there can scarcely be any difficulty in identifying it.

Although it has a broad concavity occupying the whole under side, this concavity does not seem to extend up into the very short spire, as a proper umbilicus. It is almost certainly not a true *Trochita*, because the broad under side does not have the character of a mere spiral lamina within the margin, but is really the lower side of the body volution. It seems to be more nearly related to *Xenophora*, Fischer (=*Phorus*, Montfort), or *Onustus*, Humphrey; but differs from both in not having the habit of attaching foreign bodies around its periphery, as well as in wanting the distinct umbilicus of the latter. It will probably be found to represent an undescribed group, which might be called *Pseudophorus*.

Locality and position: Monclova, Lucas county, Ohio. Corniferous group of the Devonian. It was by an oversight that the figures of this species were placed on plate 17.

Genus BELLEROPHON, Montfort, 1808.

(Syst. Class. Moll., p. 50.)

Bellerophon Newberryi, Meek.

Plate 20, fig. 5.

Bellerophon Newberryi, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 77.

Shell scarcely attaining a medium size, sub-globose in general form, and without umbilical openings, their position being occupied by a callus of the lip on each side; body volution moderately expanded at the aperture, which is rather large, transversely sub-reniform or sub-cordate, being nearly twice as wide transversely as the anterio-posterior diameter; lip apparently with a small sinus or notch in front, and rounded in outline on each side, very thin, excepting in the umbilical regions, between which it is thinly spread a little over that part of the return of the spire indenting the inner or posterior side of the aperture. Dorsal band rather narrow, not elevated above the surface of the rounded dorsum, and merely defined by a slight furrow along each side.* Surface ornamented by distinct, very regularly disposed little transverse costæ, or coarse raised lines, most strongly defined on the dorsal side, where they

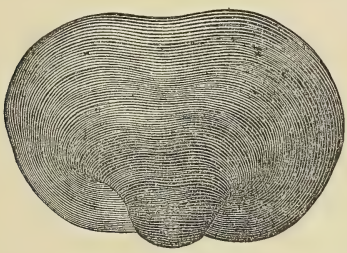
* In one of the smaller specimens the band is a little raised, so as to form a slight ridge.

curve a little backward near the band, and more abruptly in crossing the latter; while they become finer, more crowded, and again curve backward in approaching the umbilical region, where they become obsolete on each side, while they diminish to mere lines of growth, or die out, on the expanded part of the lip near the aperture. Extremely faint traces of minute revolving lines are also sometimes seen on well-preserved specimens.

Greatest anterio-posterior diameter of a mature specimen, 0.70 inch; transverse diameter of aperture, 0.72 inch.

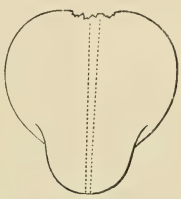
In first publishing a description of this species, I remarked that, "in its surface markings, it seems to agree with *B. patulus*, Hall;" but mentioned certain characters in which it differs from Prof. Hall's figure and description of that species: such, for instance, as its much less expanded lip, not "overlapping the volutions on the posterior side," as is said to be the case with that species; want of an open umbilicus, etc.

Since the publication of my description, Prof. Hall and Mr. Whitfield have expressed the opinion, in their list of fossils found at Louisville, Ky., that the Ohio shell is not distinct from *B. patulus*, Hall.



BELLEROPHON PATULUS.

A fac-simile of Prof. Hall's original figure, showing the great expansion of the lip.



BELLEROPHON NEWBERRYI.

An outline, showing the much less expanded character of its lip, etc. Dorsal band not *seen* to extend as far forward as the dotted lines indicate.

At the time I first studied the specimens of *B. Newberryi*, and prepared the published description of that shell, I had no New York specimens of *B. patulus* for comparison, and consequently had to rely upon memory and Prof. Hall's figure and descriptions for the characters of that species. The annexed cut is an exact copy of his figure, and I have also added, for comparison, the cut representing, in outline, the same view of *B. Newberryi*, natural size, taken from a different specimen from that figured on plate 20.

Prof Hall's original description of *B. patulus* reads as follows: "Shell slightly umbilicated, aperture suddenly and broadly dilated, nearly smooth or with faint undulating striæ, which become strong and slightly

arched in receding from the margin. The striæ become very strong and sharply arched upon the first volution."

In a more extended description of this shell, published in the 15th Report of the Regents, p. 57, he repeats that it has a small umbilicus, and that its volutions are rounded, "the last one near the aperture abruptly and widely dilated, *overlapping the volution on the posterior side.*" He farther states that "nearly all the specimens examined are more strongly striated on the back of the volution above the expansion than the one figured in the Geological Report of the Fourth District, but in other respects," he continues, "there is no important difference." He gives the transverse diameter of the aperture as a little more than one and five-eighths inches by one and a quarter inches in length, and adds that "another specimen has a diameter of aperture of nearly two inches."

Since publishing the description of *B. Newberryi*, I have, through the kindness of Prof. Hartt, of Cornell University, had an opportunity to make a direct comparison of our specimens of the same with authentic examples of *B. patulus* (belonging to the Cornell museum), from the Hamilton group of New York. None of these borrowed specimens have the expanded part of the lip entire all around, but they retain enough of it to show that it spreads out as greatly as represented in Prof. Hall's figure, while they agree perfectly in all other respects with his figure and description.

On comparing these specimens with those of our Ohio shell, I find that, as originally stated by me, and as may be seen by the annexed cuts and our figure on plate 20, the two forms not only differ in the very much greater expansion and backward extension of the lip in the New York shell, but also in the presence of a decided, open and deeply penetrating, though small, umbilicus in the same;* while in the Ohio form there is no proper open umbilicus at all, its place being occupied on each side by a callus formed by a thickening of the lip, which does not project backward beyond these points. Even when this callus is removed, there is no such decided, deeply penetrating umbilicus seen as occurs in the New York species, but only a mere minute indentation. A critical comparison of the specimens before me also shows that there are other well-marked differences. For instance, the greater expansion of the shell, although much more strongly marked at the aperture in *B. patulus*, is not entirely confined to that part, but even the involuted portion also expands more rapidly, laterally, than in *B. Newberryi;* while in the lat-

* It measures 0.10 to 0.12 inch in diameter, with abruptly inflected walls, in the New York specimens before me.

ter, these body volutions show a decidedly greater proportional dorso-ventral diameter, thus giving them a much more rounded dorsal and lateral outline.* Again, on several of the better preserved specimens of the Ohio shell, there is a narrow, well-defined dorsal band, margined on each side by an impressed line, exactly as represented in our figure 5 of plate 20; while no traces of any such band are seen on any of those of the New York species before me, all of which merely show the transverse lines to make a backward curve in crossing the middle of the dorsum, without giving origin to a band.

Whether this band continues well defined forward to the anterior margin of the lip, or even upon the expansion, in the Ohio shell, I am unable to say from observation, none of our specimens having the surface well preserved there, though it probably does, nearly as indicated by the dotted lines in the outline cut. The specimen from which that figure was drawn has the margin of the lip defective around the left side, and at the middle of the front; but its outline can be clearly seen around the right side; and as these shells are exactly symmetrical, the general outline of the lip, with the exception of the little break at the middle of the front, can be relied upon as natural in the cut, especially as it agrees with that of the specimen from which figure 5 of plate 20 was drawn, in which the outline can be traced nearly all around. I should also remark here, that since the figure on plate 20 was drawn and the annexed cut was prepared, a more careful examination of the specimen figured on plate 20 has nearly satisfied me that there is a decided little notch at the middle of the lip in front, entirely unlike the broad, faint sinuosity shown in Prof. Hall's figure of *B. patulus*.

From the foregoing remarks it will be seen that, in reviewing the subject, with the aid of New York specimens of *B. patulus* for comparison, I have seen no reason to modify my original conclusion, that *B. Newberryi* is specifically distinct from *B. patulus;* though I do not thereby mean to assert that the latter species may not also occur in the Western States.

Locality and position: Dublin, Franklin county, Ohio. Corniferous group.

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* Measurements of the involuted turns of the two species show that the dorso-ventral diameter of those of *B. Newberryi* is *constantly* one-fourth to one-third greater than those of *B. patulus*, at all points where the transverse diameters of the two are exactly equal.

Bellerophon propinquus, Meek.

Plate 20, figs. 4 *a*, *b*.

Bellerophon propinquus, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 78.

This species, so far as its characters are known, agrees so nearly with the last, in form and size, that it may be sufficiently characterized by pointing out the few characters in which it differs. In the first place, its transverse lines are distinctly finer, more crowded, and less regularly arranged; while it has a small umbilical perforation not entirely closed by the thickened lip on each side, as we see in that species. Again, its dorsal band is always distinctly elevated, very narrow, and furrowed along the middle, so as to present a biangular appearance, while the transverse lines bend back more strongly in approaching this band than in *B. Newberryi*, and do not impart the crenated or sub-imbricated appearance in crossing the band seen on this part of that species. It is likewise destitute of the very fine obscure revolving striæ of the *B. Newberryi*, and seems to have its aperture somewhat less expanded, though none of the specimens I have yet seen are in a condition to show the expansion of the aperture satisfactorily.

Locality and position: Same as last.

Genus PLEUROTOMARIA, Defrance, 1826.

(Dict. Sci. Nat., p. 381, Vol. XLI.)

Pleurotomaria Lucina, Hall?

Plate 20, fig. 6.

Euomphalus? rotundatus, Hall, 1843; Geol. Rep. 4th Dist. N. Y., p. 172, fig. 4 (not *Pleurotomaria rotundata*, Munster, 1841?).
Pleurotomaria Lucina, Hall, 1862; Regents' 15th State Cab. Report, p. 42, pl. 5, fig. 12.

Shell turbinate, very thin; spire moderately prominent; volutions three, increasing rather rapidly in size, all regularly rounded, last one comparatively large and ventricose; suture deep; aperture apparently circular; axis imperforate. Surface elegantly cancellated by regular, equal, rather strong thread-like revolving and transverse lines, the latter of which curve backward a little near the spiral band, which is narrow, a little convex along the middle, and crenated by the crossing of the slightly curved transverse lines, so as to present the appearance of the edge of a finely milled coin; a space just below the band, of the same

breadth as the latter, being without revolving lines, gives the band the appearance of having twice its true breadth.*

Height, 1 inch; breadth, 0.97 inch.

This shell agrees so nearly in form and proportions, as well as in its ornamentation, with Prof. Hall's figure of the species described by him under the name *P. Lucina*, that I have concluded to refer it provisionally to the same. Still I do so with considerable doubt, because if his figures and descriptions are *strictly accurate*, our shell would be clearly distinct, for the following reasons: In the first place, its spiral band is really not more than half the proportional breadth of that seen on Prof. Hall's figure, and differs in having a ridge along the middle, distinctly crenated by the crossing of the transverse lines; while it also passes around so as to be seen on the volutions of the spire, a little above the suture. In the figure, however, of *P. Lucina*, referred to, it is represented as being not only flat and much wider, but as *not appearing on the volutions of the spire, above the suture*, at all; which latter character would place it in the separate group for which Deslonchamps has proposed the name *Cryptotæna*. Again, a cast figured in the Report on the 4th Geological District of New York (p. 173), under the name *Euomphalus rotundatus*, and now regarded by Prof. Hall as belonging to his *P. Lucina*, is there described as having the "umbilicus large"; while in the description of the shell of this species, in the Regents' Report cited, the under side of the body volution is also said to be "depressed into the umbilicus." Yet in our specimen of the shell here under consideration, there is not even *a minute umbilical perforation*. It is true, an internal cast would show a small perforation left by the columella, but this could not be properly described as a *large* umbilicus.

If I were sure that Prof. Hall's figure is correct in the characters mentioned, particularly in not having the spiral band exposed on the volutions of the spire, I should certainly regard our shell as belonging to an entirely distinct species; but as the figure may not be exact in these characters, I am left in doubt in regard to the identity of our shell with *P. Lucina*. Should it be distinct, however, it might be designated as *P. hyphantes*, in allusion to its beautiful textile style of sculpturing.

Locality and position: Dublin, Franklin county, Ohio. Corniferous group of the Devonian system.

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* This flat space just below the band is represented proportionally too broad in our figure, so that it has too much the appearance of being itself the band, which passes around immediately above, and, from its narrowness, might be overlooked.

Genus CONULARIA, Miller, 1818, M.S.

(Sowerby Man. Conch. III., p. 108.)

Conularia elegantula, Meek.

Plate 23, fig. 4.

Conularia elegantula, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 85.

Shell presenting the usual quadrangular pyramidal form, with a divergence of the sides from the rather pointed apex, forming an angle of about eighteen degrees; each of the four lateral angles slightly rounded and distinctly furrowed; sides equal, nearly flat, and without any well-defined longitudinal mesial furrows. Surface ornamented by numerous very small; closely arranged transverse lines, that arch gently forward or toward the aperture, and sometimes become slightly interrupted and alternating along the middle of each side, while in other instances they are merely a little deflected and continuous across this slight impression or imaginary line. These lines attain their largest size, and are separated by spaces of their own breadth, at about 0.70 inch from the apex, and beyond this become gradually smaller and more crowded toward the aperture. When largest and widest apart, they number about seven in one-tenth of an inch. They are all crenulated, there being fourteen of the crenulations in a length of one-tenth of an inch. Furrows between the transverse lines, marked by very fine striæ running in the direction of the longitudinal axis of the shell, and much smaller and more crowded than the crenulations *on* the striæ.

Length of a specimen, apparently nearly entire, 1.70 inches; breadth, about 0.59 inch.

This species is related to *C. byblis* of White (Proc. Bost. Soc. N. H., Feb'y, 1862, p. 22), and *C. multicostata*, M. and W. (Proceed. Acad. Nat. Sci., Philad., Dec'r, 1865, p. 252), from the Waverly group of Iowa and Ohio. It differs, however, in having its transverse lines smaller and more crowded, there being about seventy of them to the inch, at the point where they are largest and widest apart, and one hundred in the same space near the larger end of the shell; while in both of the Waverly species mentioned, only forty-five to fifty occur in an inch. The crenulations of the transverse striæ are also smaller and more crowded in the species under consideration, there being usually fourteen of them in the tenth of an inch, which would give one hundred and forty to the inch; while, according to Prof. Winchell's measurements, they are so

much larger and more distant in *C. byblis*, that sixty to seventy-five of them would occupy the same space. The obtusely rounded and smooth apex mentioned in Dr. White's description, if natural, would be another very important distinction; but I suspect, from the appearance of some of the specimens of species of this genus figured by Prof. Barrande, that this is due to the removal of the apex by some accident, so as to expose one of the smooth septa within.*

Compared with *C. Niagarensis*, Hall, the species under consideration evidently differs in being much more gradually tapering, and has the transverse lines much smaller and more crowded toward the larger end of the shell. In form it agrees more nearly with *C. simplex* of Barrande, which, however, has the furrows between the transverse lines smooth, and these lines not becoming smaller and more crowded towards the aperture from a point six to seven-tenths of an inch from the apex.

Locality and position: Delaware, Ohio. Corniferous division of the Devonian.

CEPHALOPODA.

Genus CYRTOCERATITES, Goldfuss, 1830?

Cyrtoceratites Ohioensis, Meek.

Pate 23, figs. 2 and 2 *b*.

Cyrtoceras Ohioense, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 86.

Shell long, slender, and gently arched, very gradually tapering; section a little oval, or nearly circular, the dorso-ventral diameter being slightly greater than the transverse. Septa distant from each other, on the outer or convex (ventral) side of the curve, slightly more than one-sixth, and, on the inner side, about one-seventh the dorso-ventral diameter. Siphuncle situated near the outer side of the curve, but not exactly marginal. Surface ornamented by small, somewhat irregular annular ridges and striæ, that curve a little backward in crossing the ventral side. Rather distinct, raised lines also mark the surface longitudinally, so as to form, with the annular markings, a somewhat cancellated appearance.

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* Since seeing these figures of Prof. Barrande's, I am led to think it probable that *C. byblis*, White, and *C. multicostata*, M. and W., may belong to one species, the supposed obtusely rounded, smooth apex of *C. byblis* being the principal character that led to the supposition that *C. multicostata* was quite distinct. A comparison of specimens, however, might show other distinctions.

Length of a specimen incomplete at both ends and septate throughout (excepting about one inch of the anterior end), 6.50 inches, measuring along the convex side of the curve; dorso-ventral diameter at the posterior end, 1.33 inches; transverse diameter at the same place, 1.27 inches. The increase in size is such that the same measurements at a point three inches farther forward are respectively 1.56 and 1.50 inches; while from this point to the broken anterior end, which includes only about one inch of the body chamber, the shell diminishes a little in both diameters, but apparently more in the transverse than the dorso-ventral, though this may be in part due to accidental lateral pressure.

This species seems to be related to *Cyrtoceras eugenium*, Hall (Regents' 15th Rep., p. 70, pl. 9, figs. 1, 2 and 3), but evidently not only attained a larger size, but differs in having its dorso-ventral diameter a little greater than the transverse, instead of the reverse. It also differs in being marked with distinct longitudinal raised lines, as well as in tapering somewhat, from the central region forward, and in having its septa more closely arranged. In form it agrees less nearly with several of the Bohemian species figured by Dr. Barrande; but it differs from all of these in its surface markings, while from his *C. pugio*, which has somewhat similar sculpturing, it differs in being a little more curved, and without transverse undulations.

The entire shell could scarcely have been less than twelve or fourteen inches in length, and probably curved so as to form about one-fourth of a circle.

Locality and position: Dublin, Franklin county, Ohio. Corniferous group of the Devonian series.

Genus GYROCERATITES, Meyer, 1831.

(Nov. Act. Acad. Caes. Leop. XV., 2, p. 72.)

Gyroceratites (?Trochoceras) Ohioensis, Meek.

Plate 22.

Gyroceras (*Trochoceras?*) *Ohioense*, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 87.

Shell attaining a large size, oval-sub-discoid, composed of three or four rather rapidly enlarging whorls, the under ones of which are closely contiguous, while the last one seems to become a little free at the aperture; umbilicus large and of moderate depth. Volutions rounded, subquadrangular, with the transverse diameter somewhat greater than the

dorso-ventral, rather broadly flattened on the periphery, and compressed convex on the sides, which round off gradually into the umbilicus, and more abruptly to the periphery, excepting in young shells, which have the sides of the volutions more flattened, and rounding as abruptly into the umbilicus as to the flattened outer side. Septa moderately distant, or separated by spaces which measure, on the middle of each side, about one-third the dorso-ventral diameter of the volution at the same point; all curving gracefully backward as they cross the sides, and forward as they pass from the sides to the flattened periphery, in crossing which they again make another, but stronger backward curve. Body-chamber large, or occupying more than half the outer volution. Surface (of cast) ornamented by small transverse ridges, of which about thirty may be counted to a side of each volution, the outer half only of which they occupy, without passing over or upon the periphery; while on the inner volutions they are sometimes so short as to assume rather the aspect of transversely elongated nodes. Siphuncle, aperture and finer surface markings unknown.

Greatest diameter across the disc of a specimen with a part of the outer volution broken away, about 9 inches; dorso-ventral diameter of outer volution at the point where it is broken off, 3.63 inches; thickness, or transverse diameter of same at same point, about 3.90 inches.

Owing to the fact that the only two specimens of this species I have seen are both in such a condition as to show clearly only one side (the upper side, if it is a *Trochoceras*), I am in some little doubt whether it is a *Gyroceras* or a *Trochoceras*. From the depth of the concavity of this side, however, I can scarcely doubt that the volutions are really coiled in the same plane as in *Gyroceras* and *Nautilus*. The contiguous character of its volutions (excepting, apparently, the last one near the aperture) is, however, rather against its being a *Gyroceras*, though the inner turns are sometimes in contact in species apparently belonging to that genus. If the last turn really does become free, as seems to be the case, this character would be equally against the probability of its being a *Nautilus;* but as the specimens are not in a condition quite to remove all doubts on this point, it is barely possible that this shell may be found to belong to some of the sections of that group, though I can scarcely think so.

I know of no described species of *Gyroceras* so nearly allied to this, specifically, as to require a close comparison.

Locality and position: Delaware, Ohio, and in Marion county of the same State. Corniferous limestone of the Upper Helderberg series (Devonian).

Gyroceratites (? Nautilus) inelegans, Meek.

Plate 21.

Gyroceras (Nautilus?) inelegans, Meek; Proceed. Acad. Nat. Sci., Philad., p. 89.

Shell attaining a large size, sub-discoidal. Volutions about two and a half to three, increasing rapidly in size, having a somewhat greater dorso-ventral than transverse diameter, being moderately compressed on each side, narrowly rounded over the periphery, and rounding regularly into the umbilicus, which is of moderate depth, and distinctly narrower than the dorso-ventral diameter of the outer whorl. First turn apparently slightly embraced by the second, which seems to become free towards the aperture. Septa rather distant, deeply concave on their anterior faces, and crossing the sides and periphery with very slight backward curves; all separated from each other on the periphery by spaces equaling about half the dorso-ventral diameter at the point of measurement. Body-chamber large, or forming half of the outer volution; aperture not expanded; lip sinuous on the outer side. Surface of cast sometimes showing on the inner volutions some very faint traces of rather distant transverse ridges, which become nearly or quite obsolete on the outer turn. Siphuncle and finer surface markings unknown.

Greatest diameter across the disc of a specimen a little compressed by accidental pressure, 9 inches; dorso-ventral diameter of last turn near the aperture, 4.10 inches; transverse diameter of same, 3.50 inches.

This is another form in regard to the generic characters of which I am in doubt. Its more rapidly expanding volutions, more rounded periphery, proportionally narrower umbilicus, and closely contiguous or even slightly embraced inner turn, give it a much more Nautiloid look than the last, and I should scarcely hesitate to refer it to the genus *Nautilus*, if it were not for the fact that the outer volution seems to be a little detached at the aperture. Still this may possibly be due to compression.

Locality and position: Corniferous group of the Devonian, Marion county, Ohio.

ARTICULATA.

CRUSTACEA.

Genus PROETUS, Steininger, 1831.

(Mem. Soc. Geol. France, Vol. I., p. 355.)

Proetus planimarginatus, Meek.

Plate 23, figs. 3 *a*, *b*.

Proetus planimarginatus, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 89.

Pygidium depressed, semi-elliptic, the length and breadth being nearly as five to seven; anterior margin very gently arcuate or convex in outline; posterior somewhat narrowly rounded; lateral margins diverging forward, with slightly convex outlines, to the anterior lateral angles which are not truncated. Mesial lobe rather depressed, but rounded and well defined, narrow, or only a little more than half as wide at its anterior end as the lateral lobes, tapering gradually, with straight sides, to its posterior extremity, which terminates, at a distance of about half the breadth of the anterior end, within the margin; provided with about twelve or thirteen nearly straight segments, most of which are well defined. Lateral lobes gently convex, sloping gradually from near the middle to the lateral and posterior margins, which are horizontally flattened, but not thickened; segments eight or nine, not extending upon the flattened margin, and each divided its entire length by so broad a furrow (flat within) that only a very narrow anterior and posterior margin is left projecting, and merely separated from that of the contiguous segment by a faint linear depression; thus presenting the appearance of narrow ribs or segments, longitudinally marked by faint linear furrows, and separated from each other by broad flattened depressions. Surface apparently nearly smooth. Other parts unknown.

Length of pygidium, 0.64 inch; breadth, 0.94 inch; height of lateral lobes, 0.13 inch; do., to top of mesial lobe at its anterior end, 0.23 inch.

The pygidium of this species seems to present much the same general outline as the corresponding part of *P. Haldemani*, Hall, from the Hamilton group; but it has a proportionally narrower mesial lobe (which scarcely equals one-fourth the entire anterior breadth, instead of one-third), and a smaller number of segments in the lateral lobes. It also differs in having a distinctly flattened, instead of a thickened, border.

If I have correctly understood the nature of the segments of its lateral lobes, they are also very different from those of *P. Haldemani*, being provided with wide flattened longitudinal furrows. These furrows are so wide and strongly defined, that I have been in some doubt whether they ought not rather to be regarded as the divisions between the segments, than as the furrows of the segments themselves. On tracing them inward, however, to the mesial lobe, they are found to be abruptly narrowed and curved slightly forward, as they approach the latter, so as to seem to correspond to the furrows *on* the segments, rather than to depressions *between* them.

None of the specimens show much of the surface, but as far as it can be seen, it seems to be smooth, and to coincide exactly with the smallest elevations and depressions of the internal cast, from which the foregoing description was drawn up.

Locality and position: Upper part of the Corniferous group, Sylvania, Lucas county, Ohio. Devonian. Mr. Gilbert's collection.

Genus DALMANITES, Barrande, 1852.

(Silur. Syst., Boh. I., expl., pl. 21, etc.)

Dalmanites Ohioensis, Meek.

Plate 23, fig. 1.

Dalmanites Ohioensis, Meek, 1871; Proceed. Acad. Nat. Sci., Philad., p. 91.
Compare *D. Helena*, Hall, 1862; Regents' 15th Report, p. 89.

Pygidium large, depressed, semi-elliptic in general outline, nearly straight or gently convex in outline on the anterior margin, with the lateral angles a little rounded; posterior extremity somewhat raised and truncated, with the lateral angles of the truncated margin produced into two rather short, distinctly converging spines. Mesial lobe narrow, or only equaling half the breadth of each lateral lobe at the anterior ends, depressed and gradually tapering to the posterior end, which terminates very near the truncated posterior margin, while it is rather distinctly separated by the furrow on each side from the lateral lobes; segments about eighteen, passing straight across, and separated by well-defined furrows, that are narrower than the segments themselves, which are not furrowed. Lateral lobes most convex along somewhat within the middle, where they are nearly or quite as high as the mesial lobe, toward which they slope slightly on the inner side, while beyond the middle they slope off gradually to the lateral margins, which are very narrow,

not thickened above, and curve outward nearly horizontally; segments about fifteen, widening slightly outward, and separated by deep, well-defined furrows, extending very nearly to the lateral margins; the larger ones showing faint traces of a slender, longitudinal furrow along the middle, while all, excepting a few of the smallest posterior ones, are produced beyond the lateral margins in the form of slender, sharp, rounded spines, that curve a little backward and upward. Surface nearly or quite smooth. Thorax and cephalic shield unknown.

Length of pygidium, 1.70 inches; breadth, 2.70 inches; height, or convexity, 0.25 inch; breadth of posterior truncation, 0.45 inch; length of longest spines projecting from lateral margins, 0.38 inch.

This trilobite seems to be closely allied to *D. myrmecophorus* (=*Asaphus myrmecophorus*), Green, to which I was at one time inclined to refer it. A careful comparison, however, with the descriptions of that species given by Green, and subsequently by Prof. Hall, seems to show that our fossil cannot be properly considered identical. In the first place, it differs in having the mesial lobe only just half as wide as each of the lateral (measuring both at their anterior ends), instead of only about one-third as wide (see dimensions *D. myrmecocphorus*, given in 15th Regents' Report, p. 88). Again, it shows no traces whatever of nodes or spines (excepting the marginal spines) on any of the segments either of the mesial or lateral lobes; while in Green's species these gments of the lateral lobes are described, in the Regents' Report above cited, and also by Green, as being marked by one or two rows of nodes, and those of the mesial lobe are described in the Regents' Report as being marked each by three spines. Our species also shows a faintly impressed mesial line along each segment of the lateral lobes, not mentioned either by Hall or Green in describing *D. myrmecophorus*.

Green gives the number of segments in the middle lobe of the pygidium as fourteen, and in each lateral lobe as thirteen; while in apparently a larger specimen (three inches in length) Prof. Hall counted twenty-four segments in the axis, and twenty in each lateral lobe; from which we may infer that the number of segments varied somewhat with the size of the specimen in that species.

Although nothing is known of the cephalic shield of this species, or, I believe, of that described by Green, I have little or no hesitation in expressing the opinion that at least the form here under consideration possessed the peculiar perforated or digitated extension of its anterior margin seen in *D. selenurus*, and hence that it belongs to Mr. Conrad's sub-genus *Odontocephalus*.

Another specimen in the collection from the same locality and position as that from which the foregoing description was made out, consisting of a rude cast of the pygidium, shows the same proportional breadth of the mesial and lateral lobes, and apparently about the same number of segments, but differs in being proportionally longer, its length being to its breadth as about 8 to 11, instead of about 8 to 13. It also differs in having the spines on each side of the truncated posterior extremity distinctly larger than in the form above described, and directed straight backward, as in *D. selenurus*, instead of converging, as in the last. The spines along its lateral margins, however, are, on the contrary, proportionally decidedly smaller. This, I suspect, belongs to a distinct species, but as the specimen is too eroded to show its surface characters clearly, I have preferred to refer it doubtfully, for the present, to the same.*

Locality and position: Marblehead, Ohio. Corniferous group of the Devonian.

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* Since the publication of the foregoing description and remarks, Hall and Whitfield have referred this form, in their list of the Louisville fossils, to *D. Helena*, Hall, described in the Regents' 15th Report, p. 89. I have no other means of forming an opinion in regard to the relations of our specimens to Prof. Hall's species (which has not yet been figured), than by comparison with his published description of the same; and I can only say that if his description is *accurate*, our trilobite certainly *ought* to be a distinct species. He describes the form and proportions of the pygidium of his species so as to conform pretty nearly with ours, but *distinctly states* that it has the "lateral lobes marked by 18 or 19 ribs, *which terminate in a narrow, thickened, somewhat undulating border*." Not a word is said about the border showing any indications of being armed with slender, sharp, produced marginal spines, such as are seen on the form under consideration. Again, he describes the surface of his species as "granulose; *ribs marked by two rows of nodes or short spines*." Our figure was drawn from a good gutta-percha cast, made in a well-defined natural mould of the external surface of the pygidium, in a compact limestone matrix; and I am sure that there are no traces of the two rows of nodes or spines mentioned on the ribs of *D. Helena*, to be seen in this mould of the exterior, where they ought to be well marked, if they existed.

LIST OF FOSSILS

DESCRIBED IN THE PRECEDING REPORT.

FOSSILS OF THE CINCINNATI GROUP.

RADIATA.

ECHINODERMATA.

CRINOIDEA.

GENUS HETEROCRINUS, Hall.

Heterocrinus constrictus ..... Hall.
— exilis ..... Hall?
— simplex ..... Hall.
— juvenis ..... Hall.
— heterodactylus ..... Hall?
— laxus ..... Hall.
— subcrassus ..... M. and W.

GENUS ANOMALOCRINUS, Meek and Worthen.

Anomalocrinus incurvus ..... M. and W.

GENUS POTERIOCRINITES, Miller.

Poteriocrinites (Dendrocrinus) Cincinnatiensis ..... Meek.
— polydactylus ..... Shumard.
— posticus ..... Hall.
— Dyeri ..... Meek.
— caduceus ..... Hall.
— Casei ..... Meek.

GENUS GLYPTOCRINUS, Hall.

Glyptocrinus decadactylus ..... Hall.
— Dyeri ..... Meek.
— Dyeri var. sub-globosus ..... Meek.
— Nealli ..... Hall.
— parvus ..... Hall.
— Baeri ..... Hall.

CYSTOIDEA.

GENUS LEPOCRINITES, Conrad.

Lepocrinites Moorei ..... Meek.

GENUS ANOMALOCYSTITES, Hall.

Anomalocystites (Ateleocystites) balanoides ..... Meek.

GENUS LICHENOCRINUS, Hall.

Lichenocrinus Dyeri ..... Hall.
— crateriformis.. ..... Hall.

GENUS HEMICYSTITES, Hall.

Hemicystites stellatus ..... Hall.
— (Cystaster) granulatus ..... Hall.

GENUS AGELACRINITES, Vanuxem.

Agelacrinites (Lepidodiscus) Cincinnatiensis ..... Roemer.
— pileus ..... Hall.
— vorticellata ..... Hall.

ASTEROIDEA.

GENUS PALÆASTER, Hall.

Palæaster? Dyeri ..... Hall.
— granulosus ..... Hall ?
— ? Jamesii ..... Dana.
— incomptus ..... Meek.
— Shaefferi ..... Hall.

GENUS STENASTER, Billings.

Stenaster grandis ..... Meek.

OPHINROIDEA.

? GENUS PROTASTER, Forbes.

Protaster granuliferus ..... Meek.

MOLLUSCA.

POLYZOA.

GENUS PTILODICTYA, Lonsdale.

Ptilodictya (Stictopora) Shafferi ..... Meek.

BRACHIOPODA.

GENUS LEPTÆNA, Dalman.

Leptæna sericea ..... Sowerby ?

GENUS STROPHOMENA, Rafinesque.

Strophomena rhomboidalis ..... Wilckens.
— nutans ..... James.
— planumbona ..... Hall.

Strophomena plicata ..... James.
— planoconvexa ..... Hall.
— filitexta ..... Hall.
— sulcata ..... De Verneuil.
— sinuata ..... James.
— alternata ..... Emmons.
— alternata, var. nasuta ..... Conrad.
— alternata, var. alternistriata ..... Hall.
— alternata, var. loxorhytis ..... Meek.
— alternata, var. fracta ..... Meek.

Genus ORTHIS, Dalman.

Orthis retrorsa ..... Salter?
— subquadrata ..... Hall.
— occidentalis ..... Hall.
— insculpta ..... Hall.
— borealis ..... Billings.
— bellula ..... James.
— ? ella ..... Hall.
— fissicosta ..... Hall.
— plicatella ..... Hall.
— triplicatella ..... Meek.
— emacerata ..... Hall.
— emacerata, var. multisecta ..... James.
— (Platystrophia) biforata ..... Schlotheim.
— (Platystrophia) lynx ..... Von Buch.
— (Platystrophia) laticosta ..... James.
— (Platystrophia) dentata ..... Pander?
— (Platystrophia) acutilirata ..... Conrad.

Genus RHYNCHONELLA, Fischer.

Rhynchonella dentata ..... Hall.
— capax ..... Conrad.

Genus ZYGOSPIRA, Hall.

Zygospira modesta ..... Say.
— Cincinnatiensis ..... James.
— Headi ..... Billings.

Genus RETZIA, King.

Retzia (Trematospira) granulifera ..... Meek.

Genus PHOLIDOPS, Hall.

Pholidops Cincinnatiensis ..... Hall.

LAMELLIBRANCHIATA.

Genus AMBONYCHIA, Hall.

Ambonychia costata ..... James.
— (Megaptera) alata ..... Meek.
— (Megaptera) Casei ..... M. and W.?

GENUS CYPRICARDITES, Conrad.

Cypricardites Sterlingensis.....M. and W.
— ? carinata.....Meek.

GENUS MEGAMBONIA, Hall.

Megambonia Jamesii.....Meek.

GENUS CLIDOPHORUS, Hall.

Clidophorus (Nuculites) fabula.....Hall.

GENUS TELLINOMYA, Hall.

Tellinomya? obliqua.....Hall.

GENUS ANODONTOPSIS, McCoy.

Anodontopsis? Milleri.....Meek,
— (Modiolopsis?) unionides.....Meek.

GENUS SEDGWICKIA, McCoy.

Sedgwickia (Grammysia?) neglecta.....Meek.
— ? fragilis.....Meek.
— ? compressa.....Meek.

GENUS CARDIOMORPHA, DeKonninck.

Cardimorpha? obliquata.....Meek.

GASTEROPODA.

GENUS CYRTOLITES, Conrad.

Cyrtolites (Microceras) inornatus.....Hall.
— ornatus.....Conrad.
— Dyeri.....Hall.
— ? costatus.....James.

GENUS CYCLONEMA, Hall.

Cyclonema bilix.....Conrad.

GENUS CYCLORA, Hall.

Cyclora minuta.....Hall.
— ? parvula.....Hall.

GENUS PLEUROTOMARIA, Defrance.

Pleurotomaria (Scalites?) tropidophora.....Meek.

CEPHALOPODA.

GENUS ORTHOCERAS, Auct.

Orthoceras Ortoni.....Meek.

GENUS TROCHOCERAS, Barrande.

Trochoceras? Baeri.....M. and W.

ARTICULATA.

CRUSTACEA.

GENUS CYTHERE, Muller.

Cythere Cincinnatiensis.....Meek.

GENUS ASAPHUS, Brongniart.

Asaphus (Isotelus) megistos ..... Locke?

GENUS PROETUS, Steininger.

Proetus Spurlocki ..... Meek.

GENUS CERAURUS, Green.

Ceraurus Icarus ..... Billings.

GENUS ACIDASPIS, Murchison.

Acidaspis crosotus ..... Locke?
— Cincinnatiensis ..... Meek.
— ceralepta ..... Anthnoy?

GENUS DALMANITES, Barrande.

Dalmanites Carleyi ..... Meek.

GENUS CALYMENE, Brongniart.

Calymene senaria ..... Conrad.

FOSSILS OF THE NIAGARA AND CLINTON GROUPS.

MOLLUSCA.

BRACHIOPODA.

GENUS TRIPLESIA, Hall.

Triplesia Ortoni ..... Meek.

GENUS RHYNCHONELLA, Fischer.

Rhynchonella neglecta ..... Hall.

GENUS MERISTELLA, Hall.

Meristella (Meristina?) cylindrica ..... Hall.

GENUS TRIMERELLA, Billings.

Trimerella grandis ..... Billings.
— Ohioensis ..... Meek.

GASTEROPODA.

GENUS PLATYOSTOMA, Conrad.

Platyostoma Niagarensis, *var* .....

CEPHALOPODA.

GENUS LITUITES, Montfort.

Lituites Ortoni.....Meek.

ARTICULATA.

CRUSTACEA.

GENUS LEPERDITIA, Ronault.

Leperditia alta.....Conrad.

GENUS ILLÆNUS, Dalman.

Illænus (Bumastus) insignis.....Hall.

FOSSILS OF THE CORNIFEROUS GROUP.

MOLLUSCA.

POLYZOA.

GENUS PTILODICTYA, Lonsdale.

Ptilodictya Gilberti.....Meek.
— lichenoides?.....Meek.

BRACHIOPODA.

GENUS RHYNCHONELLA, Fischer.

Rhynchonella carolina.....Hall.

LAMELLIBRANCHIATA.

GENUS AVICULOPECTEN, McCoy.

Aviculopecten parilis.....Conr.

GENUS LUCINA, Bruguiere.

Lucina (Paracyclas) Ohioensis.....Meek.

GENUS CONOCARDIUM, Bronn.

Conocardium trigonale.....Hall.
— Ohioense.....Meek.

GENUS SOLEMYA, Lamarck.

Solemya (Janeia) vetusta.....Meek.

GENUS CLINOPISTHA, Meek and Worthen.

Clinopistha antiqua.....Meek

GENUS SANGUINOLITES, McCoy.

Sanguinolites? Sanduskyensis ..... Meek.

GASTEROPODA.

GENUS PLATYCERAS, Conrad.

Platyceras multispinosum ..... Meek.
— dumosum, var. attenuatum ..... Meek.

GENUS CYCLONEMA, Hall.

Cyclonema crenulata ..... Meek.

GENUS NATICOPSIS, McCoy.

Naticopsis (Isonema) humilis ..... Meek.
— (Isonema) levis ..... Meek.
— æquistriata ..... Meek.

GENUS ORTHONEMA, Meek and Worthen.

Orthonema Newberryi ..... Meek.

GENUS TROCHONEMA, Salter.

Trochonema tricarinata ..... Meek.

GENUS EUOMPHALUS, Sowerby.

Euomphalus Decewi ..... Billings.

GENUS XENOPHORA, Fischer.

Xenophora (Pseudophorus) antiqua ..... Meek.

GENUS BELLEROPHON, Montfort.

Bellerophon Newberryi ..... Meek.
— propinquus ..... Meek.

GENUS PLEUROTOMARIA, Defrance.

Pleurotomaria Lucina ..... Hall?

GENUS CONULARIA, Miller.

Conularia elegantula ..... Meek.

CEPHALOPODA.

GENUS CYRTOCERATITES, Goldfuss.

Cyrtoceratites Ohioensis ..... Meek.

GENUS GYROCERATITES, Meyer.

Gyroceratites (Trochoceras) Ohioensis ..... Meek.
— (? Nautilus) inelegans ..... Meek.

ARTICULATA.

CRUSTACEA.

GENUS PROETUS, Steininger.

Proetus planimarginatus ..... Meek.

GENUS DALMANITES, Barrande.

Dalmanites Ohioensis ..... Meek.

GEOLOGICAL SURVEY OF OHIO.

VOL. I.—PART II.

PALÆONTOLOGY.

SECTION II.

DESCRIPTIONS OF FOSSIL FISHES.

BY

J. S. NEWBERRY.

THE

CLASSIFICATION AND GEOLOGICAL DISTRIBUTION

OF OUR

FOSSIL FISHES.

So little is generally known in regard to American fossil fishes, that I have thought the notes which I now give upon some of them would be more interesting and intelligible if those into whose hands they will fall could have a more comprehensive view of this branch of palæontology than they afford. I shall therefore preface the descriptions which follow with a few words on the geological distribution of our Palæozoic fishes, and on the relations which they sustain to fossil forms found in other countries, and to living fishes. This seems the more necessary, as no summary of what is known of our fossil fishes has ever been given, and the literature of the subject is so scattered through scientific journals and the proceedings of learned societies, as to be practically inaccessible to most of those who will be readers of this report.

I. THE ZOOLOGICAL RELATIONS OF OUR FOSSIL FISHES.

To the common observer, the class of Fishes seems to be well defined and quite distinct from all the other groups of vertebrate animals; but the comparative anatomist finds in certain unusual and aberrant forms peculiarities of structure which link the Fishes to the Invertebrates below and Amphibians above, in such a way as to render it difficult, if not impossible, to draw the lines sharply between these great groups. *Amphioxus*, the lowest of the Fishes, has a structure much simpler, and organs and senses more rudimentary, than some of the two higher of the invertebrate classes, Mollusks and Crustaceans; while in *Lepidosiren* we find an organization that is as much amphibian as piscine. In the judgment of some anatomists, the *Dipnoi*—which include *Lepidosiren* of South America, *Protopterus* of Africa, and *Ceratodus* of Australia—should be set off in a distinct class by themselves, or be united with the *Ganocephala* (the Carboniferous salamanders), as holding an intermediate position between the true Fishes and Amphibians. Nearly all fishes, however, possess in common a structure which may be very readily de-

fined. They have a fusiform body, adapted to rapid motion through a resisting medium, and they are aquatic in habit and respiration. From their mode of life—floating freely as they do in a fluid having approximately the same specific gravity as their own—they have no occasion for limbs, such as serve to support the body in antagonism to gravitation, and act as locomotive organs in the higher vertebrates. Their movements are therefore effected only by fins, into which the anterior and posterior extremities and tail are developed. As the highest efficiency of these locomotive organs is incompatible with their use as organs of prehension, they are never employed for seizing their prey, but this is accomplished by an unusual development of the mouth and its appendages. Not being required to sustain the weight of the body, the framework is much less rigid than in terrestrial animals, and the bones are softer and more elastic. This last feature in their organization has prevented the perfect preservation of many fishes in the fossil state, and has greatly increased the difficulty of the study of some groups, especially the sharks, of which the cartilaginous skeletons have generally disappeared, and the teeth, fin-rays and dermal tubercles, disconnected, and perhaps widely scattered, are all that remain.

Various schemes of classification of fishes have been proposed by different zoologists; the changes and additions made to the earlier systems having, for the most part, followed closer study and a better knowledge of their anatomy. The first scientific system of classification proposed was that of Cuvier, who divided the class of fishes into three great orders—the *Chondropterygii* (cartilaginous fishes), the *Acanthopterygii* (fishes with spined fins), and *Malacopterygii* (fishes with soft fin-rays). Agassiz, who followed Cuvier in time, divided fishes into four orders, according to the character of their scales, viz: *Cycloidii* (fishes with rounded, entire scales, as the salmon), *Ctenoidii* (fishes with serrated scales, as the perch), *Ganoidii* (fishes with brilliant, glistening, enameled scales, such as the gar-pike), and *Placoidii* (fishes with dermal tubercles or plates, such as the sharks and rays). Johannes Muller divides fishes into five orders, viz: *Leptocardia* (amphioxus), *Cyclostomata* (lampreys), *Teleostei* (bony fishes), *Ganoidei* (ganoid fishes), and *Selachii* (sharks and rays). Professor Richard Owen proposed to divide the vertebrates into two classes — *Hæmatocrya*, cold-blooded, and *Hæmatotherma*, warm-blooded animals—the class *Hæmatocrya* including Fishes, Amphibians and Reptiles. In Owen's classification, fishes may be said to comprise three of the five sub-classes of *Hæmatocrya*, viz: *Dermopteri*, *Teleostomi* and *Plagiostomi*—the first including Agassiz's *Ganoidii* and Muller's *Leptocardia;* the *Teleostomi* including the *Cycloidii* and *Ctenoidii* of Agas-

siz; the *Plagiostomi*, the sharks, rays and chimæras. Of these sub-classes of fishes, Owen makes ten orders, viz: I. *Cirrostomi* (lancelet); II. *Cyclostomi* (lamprey and hag); III. *Malacopteri* (soft finned fishes, herring, salmon, etc.); IV. *Acanthini* (cod, etc.); V. *Acanthopteri* (perch, etc.); VI. *Plectognathi* (file-fish, trunk-fish, etc.); VII. *Lophobranchii* (sea-horse); VIII. *Ganoidei* (ganoids); IX. *Holocephali* (chimæra); X. *Plagiostomi* (sharks and rays): his order XI., *Protopteri*, being considered transitional. Other systems have been framed by Hæckel, Gunther, Lutken, Cope, Gill, etc.,* but perhaps the most satisfactory, inasmuch as it includes a discussion of fossil forms, is that of Prof. Huxley, proposed within the past year. Huxley divides the class PISCES into two sub-classes, of which the first includes only *Amphioxus*, and is equivalent to "*Leptocardia*" of Hæckel. In this subdivision "the notochord extends to the anterior end of the body. There are no skull, auditory or renal organs, such as exist in the higher vertebrata. The heart is a simple tube, and the liver is saccular." In the second subclass of Huxley (=*Pachycardia*, Hæck.), "the notochord extends behind the pituitary fossa. A skull, auditory and renal organs are developed. The heart is divided into auricular and ventricular chambers. The liver has the ordinary structure." The orders into which Huxley divides the class PISCES are as follows:

1. PHARYNGOBRANCHII (*Amphioxus*).
2. MARSIPOBRANCHII (Lamprey and Hag).
3. ELASMOBRANCHII (Sharks, Rays and Chimæras).
4. GANOIDEI (Ganoids).
5. TELEOSTEI (Bony Fishes).
6. DIPNOI (*Lepidosiren*, etc.).

When we add fossil forms to the living groups of fishes, and trace the history of this class from its first appearance in far-off geological ages up to the present time, some very interesting facts are brought out; to a few of which I will very briefly allude.

In the first place, we learn from the study of fossil fishes that in all probability no fishes swam in the most ancient Silurian sea; that they began to appear in the sea of the Upper Silurian age, and in the Devonian existed in large numbers, attained a magnitude equal to that of any

* Professors Gill and Cope are agreed in separating *Amphioxus*, *Myxine* and *Petromyzon* from fishes, and in forming three classes out of the old class of fishes, viz: PISCES (which includes the sub-classes *Teleostei*, *Ganoidei* and *Elasmobranchii*), MARSIPOBRANCHII and LEPTOCARDII. (Smithsonian Miscell. Coll., No. 247; Annals and Mag. Nat. Hist., Vol. IX., 1872.)

fishes of the present day, and possessed, in some instances, a structure scarcely less highly organized than that of the highest group of modern fishes.

In tracing the history of fishes through the successive geological ages, we also find that in later times they have been greatly diversified by divergence from some of the earlier and simpler forms; and that while the number of individuals may not be greater now than in the Jurassic or Carboniferous periods, the number of genera and species is certainly much greater now than formerly. This multiplicity of form has apparently been produced by differentiation; that is, by the exaggeration of certain characters possessed by a remote ancestor, in different groups of his descendants, until nearly all traces of relationship and common parentage are lost. It will be readily understood from these remarks that fossil fishes, in many instances, present "synthetic types"; that is, a single genus and species will be found to combine characters which are distributed among different families, and perhaps orders, of living fishes; hence, before a truly comprehensive and intelligent view can be taken of the class of fishes, it is essential that the fossil forms, which are so often connecting links, and which fill many of the gaps that exist in our present fauna, should be carefully co-ordinated with living species. The study of fossil fishes becomes, therefore, intensely interesting and highly instructive to the zoologist. It is to be regretted, however, that the rarity of the remains of fishes and the imperfection of their preservation make it impossible that they should solve all questions with regard to the relationship of living fishes, or of the life-history of the class; but every year new light is thrown upon the structure and relationship of fishes by the discovery of some new or unusually well preserved fossil. I have, therefore, ventured to hope that the remains of the remarkable fishes which are for the first time made known in this report, will be objects of more than mere idle curiosity, and that they will contribute something to the better understanding of the organization and genesis of all the great groups of fishes.

As I have before said, the dismembered condition and incomplete preservation of many fossil fishes, and the entire absence of their soft parts, make it exceedingly difficult to determine in all cases accurately their relationship to each other and to living fishes. Enough, however, has been learned of their structure to permit us to group many of them with a good degree of confidence; and quite a number of families and many more genera and species have been established to receive them.

One of the most striking results of the study of fossil fishes is the discovery that in the earlier geological ages the order which includes

much the largest part of our present ichthyic fauna (the Teleosts) had no existence, and that it was only introduced in the Cretaceous period. We also learn that Placoderms and Elasmobranchs constituted the earliest groups of fishes: that during the Devonian, Carboniferous and Jurassic ages the Ganoids attained great development, and that they subsequently dwindled away—giving place to the Teleosts—until now they are represented by but seven genera on the face of the globe.

Of existing Ganoids, by far the larger number are found in North America. Five of the seven genera occur on this continent, and four of the five nowhere else. The living Ganoids are distributed among the genera *Lepidosteus* (Gar-pikes), *Amia* (Dog-fish of the Lakes), *Accipenser* (Sturgeons), *Scaphirhynchus* (Shovel-fish), and *Spatularia* (Paddle-fish)—all of which are North American—and *Polypterus* and *Calamichthys*, found in Africa.

The persistence of the ancient fishes in North America is doubtless due to the fact that certain parts of this continent are the oldest known portions of the earth's surface. The Canadian highlands have, so far as we know, never been submerged since the beginning of the Silurian, and nearly all of the interval between the Mississippi and Atlantic has existed as dry land since the close of the Carboniferous age. Hence, though exposed to extreme alternations of climate—as in the Tertiary and Glacial periods—parts of our continent have apparently always remained as asylums where some representatives of its ancient tribes of fishes have found a safe retreat, and where the chain of descent has been unbroken from remote geological ages.

A general view of the zoological relations and geological distribution of fossil fishes may be gathered from the following table, and the notes which follow it:

Table showing Classification and Geological Distribution of Fossil Fishes.

	Palæozoic.				Mesozoic.			Cenozoic.	
	L. Sil.	U. Sil.	Dev.	Carb.	Trias.	Juras.	Cret.	Tert.	Rec't.
Dipnoi									*
Teleostei							*	*	*
Placodermi		*	*						
Ganoidei									
a. Amiadæ									*
b. Lepidosteidæ			*	*	*	*	*	*	*
c. Crossopterygidæ			*	*	*	*			*
d. Chondrosteidæ			*?			*		*	*
e. Cephalaspidæ		*	*						
f. Pycnodontidæ				*	*	*	*	*	
Acanthodidæ			*	*					
Elasmobranchii									
a. Squalli		*	*	*	*	*	*	*	*
b. Rajæ						*	*	*	*
c. Chimæroidi			*			*	*	*	*
Marsipobranchii									*
Pharyngobranchii									*

So far as is at present known, no fishes belonging to the orders *Pharyngobranchii* or *Marsipobranchii* have been found in the fossil state. This is probably due to the soft and perishable nature of their skeletons and integuments. It is evident that no traces of *Amphioxus* would remain if buried in sediments at the bottom of the water it inhabits; and the same is true of the Hag (*Myxine*), though if Lampreys existed in former times it is somewhat singular that no traces of their horny teeth should have been discovered.

The *Elasmobranchii* seem to be represented in the earliest traces of fishes known, and they have continued to exist in large numbers, and apparently with no very radical change of structure, from the Devonian and Carboniferous ages to the present day. From the fact that the skeleton in the *Elasmobranchii* is generally cartilaginous, it has almost always disappeared in the process of fossilization; and the more indestructible organs—the teeth, spines, and dermal tubercles—have alone resisted decay. These are also usually disconnected and often widely separated. Hence it is exceedingly difficult to say with certainty to what order of Elasmobranchs many of these *disjecta membra* belong—whether the fishes that wore them were Sharks, Rays or Chimæroids. The teeth will, however, frequently permit us to decide this question, and it would seem that the most ancient Elasmobranchs were mainly sharks. Of these we find great numbers of spines, teeth and dermal ossicles in the sediments of the Carboniferous sea, and many, though not as many, in those of the Devonian and Upper Silurian. The teeth of these ancient sharks present all the varieties of crushing, cutting and piercing organs; and it seems that there was even a greater variety among the sharks of the ancient seas than in those of the present day. It will also be remarked, that these old-time sharks were much more generally provided with defensive spines; some of which attained dimensions entirely unparalleled in our present fauna. Another characteristic of this ancient group of cartilaginous fishes is, that their superficial bony organs were generally highly ornamented. The spines to which I have referred are often most elegantly sculptured, and the dermal tubercles are embellished in various ways to a degree rarely observed in living species. Agassiz has shown that a large part of the ancient sharks are zoologically allied to *Cestracion*—the Port Jackson shark—so that this isolated genus, of which there are now but two or three species, may be considered, like the Ganoids and Chimæroids, as a relic of a fauna once immensely developed, but now on the eve of total extinction.

The Chimæroids are now represented by the two genera *Chimæra* and *Callorhynchus*—two species only of the former and one of the latter being

known. Numerous teeth of extinct Chimæroids have been found in the Tertiary, Cretaceous and Jurassic rocks of the Old World, and it was long ago shown by Sir Philip Egerton, who described these fossil forms under the names of *Edaphodon*, *Passalodon*, etc., that the Chimæroids were numerous and attained large size in the Mesozoic seas. But up to the date of the publication of this report, no unmistakable remains of Chimæroids have been announced as discovered in Palæozoic rocks. It will be seen, however, that in the fossils which are figured and described in the present volume as different species of *Rhynchodus*, we have satisfactory proof of the existence in the Devonian seas of Chimæroids, apparently closely resembling in structure the best known of the more recent *Holocephali*. As has been remarked elsewhere, the Conodonts obtained by Pander from the Lower Silurian rocks of Russia, were described by him as the teeth of Elasmobranchs, and as affording evidence of the existence of sharks or rays at a much earlier period in the world's history than had been before suspected. Since the character of these organs is still under discussion, they can not be accepted as conclusive evidence of the truth of Prof. Pander's generalization.

The *Ganoidei*. The order of Ganoids,as at present constituted, includes among its living and fossil genera a multitude of forms, some of which seem to have very little in common. The most striking characteristics of the living Ganoids are the possession of bony or horny scales covered with enamel, the multiple valves of the *bulbus arteriosus*, the non-decussating optic nerves, and the abdominal ventral fins. It has also been ascertained that they generally have unequally-lobed or heterocercal tails, in which the vertebral column is prolonged into the superior lobe. The latter character is, however, by no means universal; although, so far as known, the caudal fins of Ganoids differ in structure from those of Teleosts. Whatever differences they may exhibit among themselves, they may in all cases be said to be *vertebrated;* that is, penetrated to a greater or less degree by the extension of the vertebral column; but in many of the Ganoids of ancient times (e. g. *Cœlacanthini*) the tail was equally divided by the prolongation of the spine—a phase of structure to which McCoy has applied the term *diphycercal*.

A large part of the Ganoids, both living and extinct, are provided with a coat of mail in a series of rhomboidal, bony and enameled scales, of which a typical example may be seen in the Gar-pike (*Lepidosteus*). But to this prevalent character we have a striking exception in the "Dog-fish" of the lakes (*Amia calva*), which is an undoubted Ganoid, but is provided with thin, circular, imbricated scales, very similar to those of most osseous fishes. On recurring to the past history of the order, we

find both of these varieties so fully represented in fossil forms that we are able to arrange them in two great groups—the Cycliferous and Rhombiferous Ganoids. If it contained only these two forms, the order of *Ganoidei* would be well defined; but we must make it hold among living fishes the strange group composed of the Sturgeon, the Shovel-fish and the Paddle-fish, in which the body is either naked or covered with large plates, and is never, properly speaking, scaled. To these fishes the name Chondrostean Ganoids is given, from the preponderance of cartilage in their structure. The co-ordination of the extinct forms with those I have enumerated is a matter of no little difficulty, since they present marked peculiarities in their exoskeletons, and their internal anatomy is necessarily unknown. By Prof. Huxley the order of *Ganoidei*, when made to include both fossil and living forms, is divided into the following sub-orders :.

1. The *Amiadæ*, having a single representative in the rivers and lakes of North America (*Amia calva*), and no member of the group is certainly known to exist in a fossil state. The characteristics of this sub-order, as given by Huxley, are cycloid scales, preoperculum, single median jugular plate, branchiostegal rays, non-lobate paired fins, and heterocercal tail.

2. The *Lepidosteidæ* include fishes which have rhomboidal, enameled scales, a preoperculum, branchiostegal rays, non-lobate paired fins, and heterocercal tails. Fishes of this group occur in the rivers and lakes of North America. Several species of the genus *Lepidosteus* also occur in Tertiary rocks. In the Cretaceous, Jurassic and Triassic strata, the *Lepidosteidæ* are represented by numerous genera—*Dapedius*, *Lepidotus*, *Æchmodus*, etc.—and in the Palæozoic formations by *Palæoniscus*, *Amblypterus* and *Eurylepis* in the Carboniferous, and perhaps *Cheirolepis* in the Devonian.

3. The *Crossopterygidæ*. The most striking character in this group is found in the paired fins, which are lobate; that is, having their solid, central portions covered with scales, and appearing like prolongations of the abdominal walls. The scales may be cycloid or rhomboid. The dorsal fins are either two in number, or, if single, very long, or composed of many subdivisions. There are no branchiostegal rays, the jugular plates are two principal, with sometimes several supplementary ones. The tail may be heterocercal or traversed centrally by the vertebral column (diphycercal). The only members of the sub-order now living are *Polypterus* of the Nile, and *Calamichthys*, which inhabits the rivers of Senegal. One of the most remarkable groups of this sub-order, found in the fossil state, is that which has been designated as the family of *Cœlacanthini*. The fishes of this group are found in the Chalk, where

they are represented by *Macropoma*, in the Jurassic, represented by *Undina*, and in the Permian and Carboniferous, where the genus *Cœlacanthus* occurs, of which three species are described in the present volume.

All of these last-mentioned fishes are characterized by hollow fin-rays —whence their name—and by paired, elliptical, jugular plates, two dorsals which are sustained by palmated, inter-spinous bones, and by diphycercal tails, through which the vertebral column extends, and bears at its extremity a minute, supplementary caudal fin. In the Devonian and Carboniferous formations a large number of genera represent the *Crossopterygidæ*, viz.: *Osteolepis*, *Diplopterus*, *Glyptolæmus*, *Megalichthys*, *Holoptychius*, *Rhizodus*, *Dipterus*, *Phaneropleuron*, and probably the American genus *Onychodus*. In some of the fishes of this sub-order the bodies of the vertebræ are ossified, and it is the opinion of Prof. Huxley that the passage from the Fishes to the Amphibians was through this group.

4. The *Chondrosteidæ*. In the fishes of this sub-order the body is naked, or more generally protected by bony plates, which cover more or less of the surface. Neither the pectoral nor the ventral fins are lobate. The branchiostegal rays are few or absent; the tail is heterocercal. The teeth are small or absent. In this group are the sturgeons (*Accipenser*) which inhabit the rivers of all the northern hemisphere, and *Spatularia* and *Scaphirhynchus*, found only in North America. These constitute all the living members of the sub-order. In the Jurassic rocks the sturgeons are represented by *Chondrosteus*, and, as I think, in the Devonian, by *Macropetalichthys*.

5. The *Cephalaspidæ*. These form a remarkable group of fishes which occur only in the Devonian and Upper Silurian rocks, and include, perhaps, the oldest well-defined fishes yet known. The tpye of this sub-order is *Cephalaspis*, which has been made well known to the students of geology through the descriptions given by Agassiz and Hugh Miller. In *Cephalaspis* the head and anterior portions of the body were covered by a broad, shovel-shaped, bony shield. The posterior portion was scaled. The other members of the group are *Pteraspis*, *Auchenaspis*, *Menaspis*, *Scaphaspis*, etc. They are all small, and their relations to living fishes are quite uncertain. Prof. Huxley has pointed out the resemblance which they bear to the Chondrosteans; comparing *Cephalaspis* with *Scaphirhynchus*, and *Pteraspis* with *Spatularia*. It is a somewhat remarkable fact that, with the exception of one well-marked species of *Cephalaspis* (*C. Dawsoni*), found by Dr. Dawson in the Devonian rocks of Gaspe, none of the *Cephalaspidæ* have been discovered in America.*

* An exhaustive monograph of the *Cephalaspidæ* has been published by Messrs. Lancaster & Powrie in the volumes of the Palæontographical Society for 1870–71.

6. The *Placodermi.* This is the name given by Pander to the group of fossil fishes called *Placoganoids* by Owen, which includes *Coccosteus*, *Pterichthys*, *Asterolepis* and *Heterostius* of Pander, and also the gigantic fishes, for the first time fully described in this report, and found as yet only in the Devonian rocks of Ohio—*Dinichthys* and *Aspidichthys.* In the Placoderms, the head and anterior portions of the body were protected by bony plates, which were for the most part united by sutures, and had the external surface studded with points or bosses of enamel. The posterior portion of the body was either naked, or covered with angular, enameled scales. The vertebral column was generally cartilaginous; but a *Coccosteus*, with true bony vertebræ, is reported to have been recently discovered.*

The remains of these singular fishes were first found in Russia (1813) by Prof. Asmuss; and by him and by Prof. Eichwald several genera were described under the names of *Asterolepis*, *Bothriolepis*, *Homostius* and *Heterostius.* The fragmentary condition of the specimens upon which these descriptions were based created considerable confusion of nomenclature. *Asterolepis* of Eichwald is now known as *Pterichthys*, and *Homostius* has been superseded by *Asterolepis;* the last two names having been firmly fixed to the icthyolites which now bear them by the graphic descriptions of Hugh Miller. Similar fossil fishes have since been found in considerable numbers in Scotland by Miller, Peach and others, in Bohemia by Barrande, and in this country by the writer. No well-marked specimens of *Pterichthys*, *Coccosteus* or *Asterolepis* have yet been met with in America, but I have a few detached plates, obtained from the Corniferous limestone at Delaware, which probably belong to *Coccosteus;* and the great fishes of the Huron shale, described in this report under the names of *Dinichthys* and *Aspidichthys*, exhibit such resemblances in structure to the Placoderms of the Old World, that we are compelled to place them in the same sub-order.

The Placoderms are eminently characteristic of the Devonian age; and the larger members of the group were not only the most highly organized, but were, from their size and armament, the most formidable of then existing animals.

The affinities of the *Placodermi* are still matters of doubt and discussion among zoologists. The cartilaginous condition of the vertebral column is the only feature in their structure that indicates a low or embryonic organization; and this is a character of somewhat doubtful significance. The vertebræ are also reported to have been sometimes ossified, as in the

* Murchison's Siluria, p. 478.

case referred to above. The amount of true bony tissue that composed their cephalic, dorsal and ventral shields, and their massive jaws, was far in excess of that secreted by most of our so-called bony fishes. Prof. Huxley, who has discussed this question with characteristic sagacity, compares the bony armor of the Placoderms with that of the plated Siluroids, and is disposed to consider them as connecting links between the physostome Teleosts—the highest of the order—and the typical Ganoids.

7. The *Acanthodidæ*. These were small fusiform fishes, of which the remains are not rare in the Palæozoic strata of the Old World, but have never yet been met with in America. Their geological range is from the base of the Devonian to the Permian. A large number of species have been described by Agassiz, Sir Philip Egerton, Mr. Powrie, Profs. Kner, Roemer and others, in the genera *Acanthodes*, *Diplacanthus*, *Climatius*, *Parexus*, etc.

The Acanthodians derive their name from the numerous and relatively large spines which are set at the anterior margins of the fins, and elsewhere on the body. These spines are implanted in the integuments like those of sharks; and like them also are often ornamented and some times set with rows of denticles. The surface of the body in the Acanthodians was covered with closely-set, shagreen-like scales; the spine was "notochordal," and the cranium mostly cartilaginous.

By Prof. Agassiz the Acanthodians were regarded as Ganoids; but Mr. Powrie considers them as Elasmobranchs, while Prof. Huxley is disposed to regard them as annectant forms between the Elasmobranchs and Ganoids.

8. The *Pycnodontidæ* are also fishes of somewhat questionable relations, though generally considered as Ganoids. In form and in some points of structure they resemble the Plectognath-Teleosts—*Balistes*, *Ostracion*, etc.—but the spinal column was cartilaginous, and the dentition consisted of a series of bony and enameled bosses set in a kind of pavement, and adapted to crushing mollusks and crustaceans. The Pycnodonts range from the base of the Carboniferous series to the Tertiary, but are now all extinct. Few Pycnodont fishes have as yet been found in the rocks of America. I have identified *Platysomus* among the fossils collected from the Coal Measures of Illinois, and have seen the teeth of undescribed Pycnodonts collected from the Lower Carboniferous of Arizona by Mr. G. K. Gilbert, from the Cretaceous of Brazil by Prof. Hartt, and from the Green Sand of New Jersey by Prof. Marsh.

II. GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION OF OUR FOSSIL FISHES.

FISHES OF THE SILURIAN SYSTEM.

Most students of geology are aware that the remains of fishes are reported as occurring in considerable numbers in the Upper Silurian rocks of Europe, and that it is generally believed that no traces of fishes have been discovered in the Lower Silurian strata of any country; and also that in America no fishes have been met with in strata of earlier date than the Devonian age. While statements of this purport correctly express the present state of our knowledge on this subject, they require a word of explanation and perhaps of qualification.

That there were no fishes in our Lower Silurian seas, seems indicated by their entire absence from the abundant and carefully made collections of fossils that have been obtained from our Trenton and Cincinnati limestones. The exposures of the Cincinnati group, for example, are so numerous and ample, and they have been studied with such industry and care, that it seems improbable, if any remains of fishes exist in this formation, that they should have been overlooked. The fidelity with which even the most delicate mollusks, radiates and crustaceans have been preserved in the sediments of our old Silurian seas, goes far to prove, that if any vertebrates had inhabited these seas, at least some fragments of them would have remained. It should be remembered, however, that all the evidence hitherto obtained on this subject is negative. Not a millionth part of the deposit from the great Trenton sea has been yet exposed to our observation; and it may happen again, as it has happened so often already, that some fortunate discovery will revolutionize, or at least modify, all our notions in regard to the fauna of the earlier geological ages.

In Russia, Prof. Pander has discovered in Lower Silurian strata a multitude of tooth-like organs, which he announced to be the teeth of fishes; and if this conclusion were accepted, the dawn of ichthyic life would be carried far backward in geological history. It should be said, however, that the views of Prof. Pander in regard to his *Conodonts* have not been accepted by other palæontologists; as the denticles which he regarded as the teeth of fishes have, by Owen and others, been considered as more probably the teeth of mollusks, or as spinous appendages of crustaceans.

In regard to the fishes of the European Upper Silurian rocks, there can be no doubt. In England twelve species have been described, from the Upper and Lower Ludlow rocks, and from the passage beds between the Silurian and Devonian systems, viz:

1. *Auchenaspis ornatus*.....Egerton.
2. *A. Salteri*..... "
3. *Cephalaspis Murchisoni*..... "
4. *Onchus Murchisoni*.....Agass.
5. *O. tenuistriatus*..... "
6. *Plectrodus mirabilis*..... "
7. *P. pustuliferus*..... "
8. *Pteraspis Banksi*.....Hux. and Salt.
9. *P. Ludensis*.....Salter.
10. *P. truncatus*.....Hux. and Salt.
11. *Sphagodus pristodontus*.....Agass.
12. *Thelodus parvidens*..... "

Of these the oldest is *Pt. Ludensis*, Salter, from the Lower Ludlow rocks, and this is the most ancient vertebrate now known. The fossils described by Agassiz, under the name of *Plectrodus* (figured in "Siluria," Pl. XXXV.), are considered by Dr. J. Harley to be the "posterior spines of the cephalic plates of some Cephalaspidian fish," but by Mr. Salter are regarded as true jaws; and he suggests that they may form the dentition of *Cephalaspis* or *Pteraspis*.

Sphagodus and *Thelodus* of Agassiz are undoubtedly the dermal tubercles (shagreen) of Selachians, perhaps of the fishes of which the spines are called *Onchus*.

In Russia a large number of genera and species of fossil fishes have been found in Upper Silurian strata. These have been described by Eichwald* and by Dr. C. H. Pander.† They were obtained mainly from the Island of Oesel, and from strata supposed to represent the Ludlow and Wenlock rocks of England. Forty-three species of Silurian fishes are enumerated as occurring in Russia; of which one only is reported to have been derived from the equivalent of the Wenlock limestone, the others all coming from the Ludlow beds. It should be said, however, that this long list of species is, for the most part, based upon fragments only, and in all probability several of these were portions of the same fish; so that it doubtless exaggerates the richness of the ichthyic fauna of the Silurian seas of Russia.

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* Bulletin de la Soc. Imp. des Natur., Moscow.

† Monographie der Fossilen Fische des Silurischen Systems, etc., St. Petersb.

Prof. Barrande has given us, in his splendid illustrations of the Silurian fauna of Bohemia, descriptions of six species of fossil fishes, viz:

Asterolepis Bohemicus.....Bar.
Coccosteus Agassizii..... "
C. Fritschi..... "
C. primus..... "
Ctenacanthus Bohemicus..... "
Gompholepis Panderi..... "

Of these, *Coccosteus primus* occurs only in Barrande's *Etage* F, *Cten. Bohemicus* in F and G, the others in G only.

It will be noticed that the English genera of Silurian fishes are all wanting in Bohemia, and that *Asterolepis*, *Coccosteus* and *Ctenacanthus* of the Bohemian list are characteristic of the Devonian strata of England.

Prof. Giebel has announced the discovery of numerous fragments of fossil fishes in the Upper Silurian strata of the Hartz, and has described three species, viz:

Dendrodus lævis.....Gieb.
Ctenoptychius Hercyniæ..... "
Ctenacanthus abnormis..... "

These come from the extreme summit of the Silurian system or the base of the Devonian.

From these facts it will be seen that in various parts of Europe the remains of fishes are met with in greater or less abundance in Upper Silurian rocks; but if we exclude the Conodonts of Pander, of which the zoological relations are doubtful, no fishes have been as yet any where found in strata of *Lower* Silurian age.

As has been already stated, no unequivocal fish remains have as yet been discovered even in the *Upper* Silurian of America, although such discoveries have from time to time been reported. Some of these reported cases require a word of explanation.

Sir Charles Lyell, in his "Travels in North America" (English edition, Vol. II., p. 37), says that he was informed by Prof. H. D. Rogers that he and his brother (Prof. W. B. Rogers) "had traced the scales of fishes through strata of Clinton age from the south-western part of Virginia to the north branch of the Susquehanna, in Pennsylvania;" but no such statement is made by Prof. Rogers in his "Geology of Pennsylvania"; and indeed he says distinctly (Vol. II., p. 824) that the oldest remains of fishes known to him are such as occur in the Corniferous limestone.

Prof. James Hall has described and figured, under the name of *Onchus*

Deweyi, what he considered the dorsal spines of fishes from the Clinton of New York (Palæontology of New York, Vol. II., p. 320, pl. 71); but it is now generally admitted that these are the spines of crustaceans and not of fishes.

The fish spine figured by Hugh Miller—"Footprints of the Creator," p. 143, copied from the American Journal of Science, 2d Ser., Vol. I., p. 62, and referred to the *Onondaga salt-group*—is really from the *Onondaga limestone*, the lower member of the Corniferous. The specimen figured is the upper extremity of *Machæracanthus major*, of which a description and figure are given in another portion of this report.

I have elsewhere shown that the specimen of *Macropetalichthys* obtained near Madison, Indiana, described by Drs. Owen and Norwood, and which was referred by these gentlemen, and, following them, by Murchison and Owen, to the Upper Silurian, was in fact found in the Corniferous limestone.

These are, I believe, all the cases which have been cited of the occurrence of fish remains in the Upper Silurian rocks of America, and each of these has been proved to be a mistake; so that I am fully justified in saying that, up to the present time, no fish remains have been found in American Silurian strata. As the progress of life seems to have been nearly the same in all parts of the world, and the most remarkable parallelism has been found to prevail between the faunas and floras of each of the great geological systems in Europe and America, it was to be expected that the remains of fishes would be found on both continents at nearly the same horizon. There is indeed a strong probability that some traces of fishes will hereafter be found in our Upper Silurian strata, but if any such exist, they have, as yet, escaped detection.

The zoological relations of the Silurian fishes have been referred to in another place, and I will only allude to them here, in order that the life history of the Class of Fishes may be properly connected with the succession of events which constitute the physical history of the globe.

The fishes found in the Upper Silurian rocks of England belong to two very distinct groups, viz., the Placoderms and the Elasmobranchs. Of these, the first includes that singular series of armor-clad fishes, such as *Pteraspis*, *Cephalaspis*, *Pterichthys*, *Coccosteus*, etc., in which the head and vital portions of the body were protected by bony, tuberculated plates. The Elasmobranchs (Placoids of Agassiz) include the shark, rays and chimæras, in which the skeleton is almost entirely cartilaginous, and the only true bony appendages are the teeth, the dermal ossicles (shagreen) and the dorsal spines. These spines are the largest bony organs, and such as are most frequently found in the fossil state. The spines of

a Selachian called *Onchus*, and the cephalic buckler of a small Placoderm, *Pteraspis*, from the Lower Ludlow rocks, constitute the oldest remains of fishes found in Great Britain. These are mentioned, as similar forms are to be looked for in our Upper Silurian rocks. The fin spines of *Onchus* indicate an affinity with the spined sharks which were so common in the Carboniferous and Jurassic seas, and which are now represented by the Port Jackson shark (*Cestracion*). All these were cartilaginous fishes, and they are thought by some zoologists to hold a low place in the scale of being, as we might naturally expect of the earliest appearing of the class of Fishes. By other, and, perhaps, equally good authority, they are assigned a relatively high place. They are certainly far removed from the most embryonic and rudimentary forms of fishes, *Amphioxus*, *Petromyzon*, etc. The affinities of the Placoderms are not yet fully established. Prof. Huxley is inclined to connect the peculiar group of small buckler-headed fishes which form the sub-order *Cephalaspidæ* with the sturgeons; while *Coccosteus*, *Pterichthys* and the larger Placoderms he compares with the living Siluroids, and is disposed to regard them as being connecting links between the scaled Ganoids and Teleosts. This conclusion has been strengthened by the recent discovery of a specimen of *Coccosteus* with ossified vertebræ (referred to p. 257).

Prof. Owen, speaking of the fish spines found in the Upper Silurian of England (*Onchus Murchisoni* and *O. semistriatus*), says: "We may infer that there co-existed a larger and more powerful predatory fish against whose attacks the *Onchus* was thus defended." This inference seems to me unwarranted, as the fishes of the Silurian were living under the "Reign of Mollusks," and the Cephalopods of both the Lower and Upper Silurian seas, from their numbers and size, must have been formidable enemies to such fishes as *Onchus*. The Cephalopod, the pneumatic apparatus of which we now call *Orthoceras Titan*, must have weighed some tons; and if at all like his congeners of the present day—the cuttle-fishes—was capable of easily overcoming any Palæozoic fish.

FISHES OF THE DEVONIAN ROCKS.

As has been already stated, the oldest remains of fishes yet found in America are obtained from the Devonian rocks. This formation has now furnished us with a long list of genera and species, part of which have been heretofore described by myself; part are described for the first time in this report; and still others, of which more or less complete portions have been obtained, remain for further study.

FISHES OF THE CORNIFEROUS LIMESTONE.

The first reference made to the ichthyic fauna of the Corniferous, so far as I can learn, is in the "Geology of the State of New York," Part IV., p. 174, 1843. There a nearly complete specimen of *Machæracanthus sulcatus*, Newb., is figured, and recognized by Prof. Hall as an ichthyodorulite. In the review of the Geology of New York (Am. Jour. of Sci., 2d Ser., Vol. I., p. 162), another species of the same genus is figured, without name or description. It apparently represents, however, the upper portion of a spine of *Machæracanthus major*, Newb.

The next allusion to the Corniferous fishes is formed by the "Description of a new Fossil Fish from the Palæozoic rocks of Indiana," by J. G. Norwood, M.D., and D. D. Owen, M.D. (Am. Jour. of Sci., 2d Ser., Vol. I., p. 367). This is based upon the cranium of a fish obtained from the Corniferous limestone, near Madison, Indiana.* The description is vague, and in many points erroneous. The figure is also very poor, but it is easy to see from it that the authors of the paper had before them an exceedingly imperfect specimen of the ichthyic cranium, since so frequently met with in Ohio, and for which I have felt compelled to retain their somewhat unwieldy name of *Macropetalichthys*.

In 1851 David Christy, Esq., exhibited to the American Association, at its meeting in Cincinnati, a jaw, with teeth, taken from the Corniferous limestone at Delaware, Ohio. This is referred to by Prof. Agassiz, in his report on the vertebrate fossils exhibited at that meeting, "as the jaw of an unknown Ganoid fish." To this fish I have since given the name of *Onychodus sigmoides*, and it will be found described and illustrated in another portion of this volume.

In 1853 a brief popular description of the head of *Macropetalichthys* was given by myself in the Annals of Science, Vol. I., p. 12. Figures were given also, in this article, of two teeth, which, because found in proximity to the cranium, were supposed to appertain to it, but we have since learned that they belong to another fish (*Onychodus*), and so far as at present known, *Macropetalichthys* was toothless.

In 1854 some interesting and beautiful specimens of *Machæracanthus* were exhibited by Prof. Wm. Hopkins at the meeting of the American Associa-

* This specimen was supposed by Messrs. Owen and Norwood to have been obtained from Upper Silurian rocks, but we now know that it was found in the Corniferous limestone. The error has been perpetuated by references made to Prof. Owen's article in Silliman's Journal, by Murchison, Owen, and other European writers. It is corrected on another page, where it is shown to be one of the many fictitious instances reported of the discovery of fishes in our Upper Silurian.

tion for the Advancement of Science. Of these specimens, figures and a brief popular notice are given in the "Proceedings" of this meeting, p. 287. They were obtained from the Corniferous limestone at Auburn, Cayuga county, and Waterloo, Seneca county, New York.

In 1857 a communication was made by the writer to the National Institute, on the "Fossil Fishes of the Devonian Rocks of Ohio." This paper was printed in the Bulletin of the National Institute for 1857. It contains descriptions of the following species:

Macropetalichthys Manni	Newb.
M. Sullivanti	"
Onychodus Hopkinsii	"
O. sigmoides	"
Psammodus antiquus	"
Machæracanthus major	"
M. peracutus	"
M. sulcatus	"
Oracanthus fragilis	"
O. granulatus	"
O. multiseriatus	"
O. abbreviatus	"

In the progress of the Geological Survey of Canada, well-marked specimens of *Machæracanthus* were found at Gaspe, which, through the kindness of Prof. Dawson, I have had an opportunity of examining.

A very fine collection of the ichthyolites of the Corniferous limestone of Delaware county, Ohio, was made some years since by Dr. Mann, of New Milford. A part of these were described by me in the paper read before the National Institute. Others yet remain to be described. Dr. Mann's collection is now in the museum of the Wesleyan University at Delaware, Ohio.

I should also mention among the fish remains of the Corniferous limestone a peculiar and interesting specimen obtained by Mr. G. K. Gilbert at Sylvania, Lucas county, Ohio. This seems to be a dorso-median plate of a Placoderm. It is about eight inches in length and breadth, rounded at one end, emarginate at the other, and evidently represents a hitherto unknown genus and species.

In this connection I will call attention to a bone-bed contained in the Corniferous limestone at North Vernon, Indiana. We here find considerable portions of the rock—a sheet sometimes two inches in thickness—in large part made up of dermal tubercles and teeth of Selachians. This deposit is the more remarkable from the fact that the remains of sharks are comparatively rare elsewhere in the Corniferous limestone: a single

mass of dermal tubercles, found by Mr. Hertzer at Delaware, forming the only other instance known to me.

Perhaps the most interesting discovery that has ever been made among the fishes of the Corniferous limestone, is that of *Chimæroids*, for the first time announced in this volume. As is well known, the group of *Holocephali* is represented in our present seas only by the genera *Chimæra* and *Callorhynchus*. Of the former genus, one species only is known; of the latter, two. The remains of Chimæroids have been found in Secondary and Tertiary strata in the Old World, and of these Sir Philip Egerton has described several genera (*Edaphodon*, *Passalodon*, etc.), the oldest having been obtained from the Jurassic rocks. In the genus *Rhynchodus*, however, of which the teeth have been found in several localities in Ohio, we have what seems to me good evidence of the existence of Chimæroids in the Corniferous sea. The specimens here referred to will be found described in detail in another part of this report, and it will be seen that they possess considerable zoological, as well as geological, interest.

The spines which I have described under the name of *Machæracanthus* are quite unlike any defensive organs worn by the fishes of the present day, and are also unlike any fish spines that have been described from any of the formations that have yielded the remains of fishes. I have elsewhere given the reasons for supposing them to be the spines of Selachians, and probably the defenses of the pectoral fins. If this was their true nature, they are without example in our recent fauna. It seems, however, that the armament of the sharks which inhabited the ancient seas was more complete than that of those of the present day. Very few of the living sharks have dorsal spines, but their abundance in some of the geological formations would seem to indicate that they were worn by a majority of the ancient sharks. The significance of this apparent difference we perhaps cannot fully comprehend at present, but it has doubtless an important zoological meaning. The changes in the "habits of good society," as illustrated by our history during the last two centuries, may perhaps help us to explain the phenomenon. A hundred years ago every gentleman wore his small sword, and was so prompt and skillful in its use that he who was without the weapon or the power to wield it, was at a great disadvantage among his fellows. When, therefore, the habit was general, it was necessarily universal. But now a general disarmament has put all members of society on an equality, though the sword element is entirely absent. In reviewing the various phases of armament, offensive and defensive, worn by the animals of different ages, we find such an infinite variety, and such

complete changes of style, that it almost seems that the caprice of fashion ruled the world in former times as now; but all this diversity was doubtless controlled by profound physiological laws. There can be little question that both utility and beauty took part in producing the varied results; and both sexual selection and the survival of the fittest combined to produce the variety we see.* A curious parallelism is discoverable in the changing styles and in the effectiveness of cotemporaneous offensive and defensive armor; and we see that all through the ages the same contest has been maintained, that is now going on between our improved projectiles and plate-armor. It is a singular fact that in the spine of *Machæracanthus* we have nearly the same principle of construction as in our bayonets. *Machæracanthus* is really a double bayonet; that is, a blade strengthened by two longitudinal central ridges, the material being economized by making the slopes from the ridges to the margins concave.

In reviewing the ichthyic fauna of the Corniferous limestone, we find that it includes, besides some imperfectly known material, the following elements :

ELASMOBRANCHS.

Machæracanthus major	Newb.
M. sulcatus	"
M. peracutus	"
Rhynchodus frangens	"
R. secans	"
R. crassus	"
Oracanthus? fragilis	"
O.? abbreviatus	"
O.? granulatus	"
Psammodus antiquus	"
Cyrtacanthus dentatus	"

GANOIDS.

Macropetalichthys Sullivanti	Newb.
M. rapheidolobis	N. & O.
Onychodus sigmoides	Newb.

*It is not claimed nor believed by the writer that these were the only influences which controlled ornamentation and armament. This is no place to discuss the question, but abundant instances can be cited where ornamentation at least is beyond the reach of any explanation afforded by either of these confessedly potent causes. For example, the ornamentation, both in color and form among the Radiates—especially in the Polyps and Echinoderms—is as elaborate and striking as in any other group of organic forms; and yet it must have been some times an incumbrance, and never an attraction, where there is no vision, and propagation is not effected by concurrence of the sexes.

Asterosteus stenocephalus ..... Newb.
Acanthaspis armatus ..... "
Liognathus spatulatus ..... "
Acantholepis pustulosus ..... "
Coccosteus ?

FISHES OF THE HAMILTON GROUP.

It is a little singular that the Hamilton group, up to the present time, has yielded very few remains of fishes. This I suspect, however, is largely due to the fact that the exposures of this formation have not been carefully examined, as we generally find those things we look for, or rather, are unlikely to find those for which we do not make a special search. Several species of fish-teeth were obtained by Prof. F. H. Bradley from the Marcellus or Hamilton shales of central New York, and an altogether new and yet undescribed genus has been found in the Hamilton at Ithaca, New York, by Mr. H. H. Smith. I have also seen in the cabinet of Yale College a large plate, evidently of a Placoderm — and different from any one with which I am acquainted — which is said to have been obtained from the Hamilton of Michigan. At Delaware, Delaware county, Ohio, there is found a bed of calcareous clay lying immediately below the Huron shale and above the Corniferous limestone; and this we have considered the representative of the Hamilton in central Ohio. In this shale Mr. Hertzer discovered a number of small concretions, each of which has a fish bone — jaw or plate — as its nucleus. These belong to small Placoderm fishes which are new to science. They will be described in a future volume of our report.

The few specimens I have enumerated are all which, so far as my knowledge goes, the Hamilton has yielded in this country; but we have every reason to expect that when this formation shall be more thoroughly searched, the remains of many other fishes will be found in it. In Ohio we can expect little from this group, as it is thin and rarely exposed; but in the State of New York, where it is thicker and much more fully opened, there is every probability that many interesting things will be obtained from it.

FISHES OF THE HURON SHALE.

This formation — the equivalent of the Genesee and Gardeau shales of New York — though extending through most of the western and southwestern States, and exposed at a thousand points, has been usually regarded as the most barren of fossils of all the members of our geological series. This is a somewhat surprising fact, when the amount of organic matter contained in this great carbonaceous deposit is considered. There

is no doubt, however, that as a general rule the Huron is very barren ground for the palæontologist. That it is not always and everywhere so, is proven by the interesting discoveries of gigantic fossil fishes made in it at Delaware by Rev. H. Hertzer, and which are referred to in other parts of this report. The larger fishes of the Huron — *Dinichthys Hertzeri*, *Aspidichthys clavatus* and *Ctenacanthus vetustus* — are so fully described on succeeding pages that no analysis of their structure or affinities is required here. I will merely call attention, therefore, to the zoological aspect which they collectively present, and to the clue which they give us to the life of the Huron epoch.

Of the fishes I have enumerated, *Dinichthys* and *Aspidichthys* were Placoderms, and the largest and most formidable of the group yet known. They were probably from ten to twenty feet in length and very massive in form. The *Ctenacanthus* was the dorsal defensive spine of a shark, perhaps eight or ten feet long. In numbers, *Dinichthys* preponderates immensely over the others, as remains of at least a hundred individuals of this genus have been found, while fragments of only two or three of *Aspidichthys* are known, and the beautiful spine of *Ctenacanthus vetustus* now figured, is unique. Nothing is known of the dentition of *Aspidichthys*, nor of that of its diminutive congener *Pterichthys*, and therefore we can not speak with any confidence in regard to the nature of their food. But we can at least say that their plate-armor must have perfectly protected them from attack, and they could not have served as food for other fishes. *Dinichthys* was eminently carnivorous; and we might infer from the extraordinary size and strength of its dental apparatus that it preyed upon fishes of large size, and such as offered obstinate resistance, positive or negative, to its attacks. The shark *Ctenacanthus*, whose dorsal spines were a foot in length, was probably carnivorous; and from the extreme rarity of the remains of mollusks in the formation where it is found, we may conclude it was not conchivorous.

Perhaps the bony shields worn by *Dinichthys* were for the protection of the wearers against the powerful jaws of their own kin. But it is very improbable that the species was, to any great degree, self-devouring; for the double reason that cannibalism is an offense against a far-reaching law of nature, and the carapaces of even the younger individuals of *Dinichthys* must have been very hard to crack, even for the all-embracing and massive jaws of their parents and adult relatives.

All that we know of the economy of ichthyic life leads us to infer, therefore, that we have in the great fishes which I have mentioned, a mere fragment of the fauna of the Huron sea, and that with these there were tribes of lesser fishes, some of which were vegetable feeders, and

these formed the base upon which the superstructure of the ichthyic fauna rested; this base being in turn supported by the great mass of plant-life from which the carbonaceous element in this deposit was derived. This view is confirmed through the discovery by Mr. Hertzer of the dismembered remains of several small fishes in the Huron shale at Delaware. These specimens are not numerous, nor are they quite sufficient for satisfactory description; but they are of interest as showing that the fishes yet obtained from the Huron shale formed part only, and probably a very small part, of the fish fauna of the Upper Devonian epoch.

Prof. O. C. Marsh has procured some fragmentary bones of large fishes from the Huron at the Falls of the Ohio, which, though too imperfect for accurate delineation, are certainly different from any found in Ohio.

FISHES OF THE CHEMUNG.

No well-marked fossil fishes have as yet been found in the Erie shale in Ohio; but in the Chemung at Franklin, Delaware county, New York, the late Mr. J. M. Way collected a large number of fish remains, and from specimens sent me from this locality by Prof. Edward Orton, it is evident that it is one of the richest in fossils of this character of any known in the country. Among the specimens received from Prof. Orton, the most abundant are teeth of a species of *Onychodus*, which I have described under the name of *O. Hopkinsii*. These are smaller than the full-grown central teeth of *O. sigmoides*, and show but a single curvature. They are scattered so thickly through the rock that a dozen may some times be seen on a square foot of surface. The only other fossils contained in the collection made by Prof. Orton are large plates of indeterminate form—of which the exterior surfaces are marked with strong radiating lines of ornamentation—and fragments of jaws (?) set with stout conical teeth; somewhat like *Plectrodus* of the Upper Silurian of England. Both these latter forms belong to fishes yet undescribed, and of which the specimens I have received give me but a very imperfect view. I infer from some drawings formerly sent me by Prof. Orton, that a large variety of fish remains are to be found in the Chemung of Franklin, New York; but without better material than I have yet had access to, I am unable to say much of the very interesting suite of specimens collected by Mr. Way. Unfortunately, he was one of the victims of our late war, and his collection has been disposed of, perhaps scattered.

The region from which these specimens were obtained is, in my judgment, one that promises more new material in the way of Palæozoic fishes than any other known in this country. In connection with the exploration of this district, it would be a matter of great interest to

trace the relation between the fish-bearing beds of the Chemung and the equally rich fish-beds of the Catskill, in the northern part of Pennsylvania.

FISHES OF THE CATSKILL.

In the northern tier of counties in Pennsylvania—Susquehanna, Bradford, Tioga and Potter—the Catskill group underlies the surface over a large area, and is well exposed in a great number of localities; but it is not certain that the formation can be found in any other district than that to which I have referred. Here it has a maximum thickness of 400 or 500 feet, mostly red sandstones and shales. Passing northward into the State of New York, the Catskill is found to be removed by erosion, and while it is probable that it has some representative in the upper beds of the Catskill Mountains, it has not as yet been identified there. The mass of these mountains is now known to be composed of Chemung rocks. In coming west from Tioga county, Pennsylvania, the Catskill thins out; and while it may be traced into Warren county, I found nothing of it nearer to the Ohio line than the valley of the Allegheny, near Warren. In most localities where it is exposed in Pennsylvania, the Catskill group is rich in the remains of fishes. These are generally bones and scales of ganoids of large size—for the most part *Holoptychius* and *Bothriolepis*. These combine with the lithological character of the rock to produce such a resemblance to the Old Red Sandstone of Scotland, that even the most experienced geologist would be unable to distinguish between specimens taken from the two sides of the Atlantic.

Though extra-limital to Ohio geology, the fishes of the Catskill form so important a feature in the palæichthyic life of the continent, that I cannot pass them without a brief notice.

The fish remains of the Old Red Sandstone of Tioga county, Pennsylvania, though referred to long before, are first described by Prof. James Hall in the Geology of New York, Vol. IV., p. 281, pl. III. (1843). Two forms of scales, a tooth, a portion of a mandible, and a large pectoral fin are figured by Prof. Hall, and are referred in part to *Holoptychius noblissimus*, Ag., a well-known fish of the Old Red Sandstone of Scotland, and partly to a new genus and species named by Prof. Hall *Sauripteris Taylori*. Subsequently (1856) Prof. Joseph Leidy described a number of the remains of fishes from Tioga county (Jour. Acad. Nat. Sciences, Phila., 2d ser., Vol. III., p. 162, pl. 16, 17). These include two kinds of scales, one of which is identical with that referred by Prof. Hall to *Holoptychius noblissimus*, the other larger, more angular, and having a granular rather

than a corrugated surface. Both these forms he considers as probably belonging to the same fish, to which he gives the name of *Holoptychius Americanus*. Prof. Leidy also figures and describes a flattened lancet-shaped tooth under the name of *Apedodus priscus;* also a denticulated spine, to which he gave the name of *Stenacanthus nitidus*.

Since the organization of the Geological Survey of Ohio, I have received from Mr. Andrew Sherwood, of Mansfield, Tioga county, Pennsylvania, a large collection of the remains of fishes, obtained in the vicinity of his place of residence. Considerable additional material from the same formation and district has come into my hands through other parties, and I hope soon to be able to publish elsewhere a fuller discussion than would be proper here of this interesting group of fishes, so different from any others found on the continent, and so closely resembling the most characteristic forms of the Old Red Sandstone of Scotland. I can now only very briefly indicate the general results of such examination as I have made of the materials in my hands, and of the published descriptions of that studied by others.

Never having seen the specimens named by Prof. Hall *Sauripteris Taylori*, I cannot speak decisively in regard to their relations; but I am led to conclude that the scales figured as belonging to that species are identical with the larger and granulated forms assigned by Prof. Leidy to *Holoptychius Americanus*. The scales referred by Prof. Hall to *Holoptychius noblissimus* are much like some of those which are figured by Agassiz in his splendid plates of *H. noblissimus* (*Poiss. Foss. d. Vieux. Gres. Rouge*), but some of those which I have, and have seen, are much larger than any of the scales of that species. It is perhaps well enough to consider them as the scales of *H. noblissimus* until proof to the contrary is found; but it should be understood that much more material must be obtained before the specific identity of the scales found in England and Pennsylvania can be said to be established, and before any important deductions are made from them.

The two forms of scales regarded by Prof. Leidy as belonging to his *H. Americanus*, as my specimens prove, appertain to different fishes, one of which is the so-called *H. noblissimus*, and the other apparently a *Bothriolepis*. If, as seems probable, the latter is identical with the fish described by Prof. Hall as *Sauripteris Taylori*, it should be hereafter called *Bothriolepis Taylori*. In Prof. Dana's excellent "Manual," p. 292, fig. 509, a scale of this fish is represented with the name of *Holoptychius Taylori;* but in my judgment the fish which bore it was generically distinct from *Holoptychius*, as the scales were *not imbricated*, and the exterior surface was entirely covered with an ornamentation different from that of any

known species of *Holoptychius*, and precisely like that ascribed by Agassiz to his genus *Bothriolepis*.

If now we take a retrospective view of the ground gone over in the preceding notes, and compare the ichthyic fauna of the American Devonian with that of the same geological system of the Old World, we shall find some marked differences, and even contrasts, which suggest inquiry, and for which it would be pleasant to be able to give a full explanation. The most conspicuous difference between the American and European Devonian fish faunæ, is the entire absence from all our collections of many of the most abundant and best known genera of the Scotch and English Old Red Sandstone fishes. For example, we have as yet found in America no traces of *Pteraspis*, *Auchenaspis*, *Scaphaspis*, *Menaspis*, *Pterichthys*, *Asterolepis*, *Osteolepis*, *Dipterus*, *Diplopterus*, *Glyptolepis*, *Platygnathus*, *Cheiracanthus*, *Diplacanthus*, *Cheirolepis* or *Climatius;* while of *Cephalaspis*, only one well marked specimen has been obtained, viz., *C. Dawsoni*, from the Devonian of Gaspe, Canada, and *Coccosteus* is only doubtfully represented by a dorsal plate from the Corniferous limestone of Delaware, Ohio.

On the other hand, nearly all the most important ichthyolites of our American Devonian are unknown in Europe. For example, no traces of *Dinichthys*, *Aspidichthys*, *Machæracanthus*, *Macropetalichthys*, *Onychodus* or *Acanthaspis* have been found in the British Islands, and only one of these, *Macropetalichthys*, has been met with on the continent of Europe.

Another fact of interest is, that the only American representatives yet known of *Holoptychius* and *Bothriolepis* are found in the Catskill group (which has been regarded as the extreme summit of the American Devonian), in Northern Pennsylvania.

In comparing the American and foreign Devonian fishes zoologically, it will be noticed, First, that up to the present time, not a trace of the little Acanthodian fishes—*Cheiracanthus*, *Diplacanthus*, *Climatius*, etc.—have been found in this country. Second, among the Placoderms we have *Dinichthys* and *Aspidichthys* as representatives of *Coccosteus* and *Pterichthys*, but exceeding their European congeners at least a hundred fold in bulk. Third, we have none of the lobate-finned Ganoids—*Crossopterygidæ*—in the fauna of the Corniferous limestone, unless *Onychodus* be a gigantic member of this group; and our only other Devonian Crossopterygian fish is *Holoptychius* of the Catskill. Fourth, a striking feature, which the Devonian fish faunæ of both countries have in common, is the great preponderance of Ganoids over Elasmobranchs.

When now we come to seek an explanation of the differences that have been referred to, we shall perhaps be somewhat helped to a con-

clusion by noticing the nature of the strata containing fossil fishes in the two countries. In America, by far the greater number of Devonian fishes have been obtained from the Corniferous limestone, plainly an open sea deposit, and they are nearly all of large size. The Huron shale, which contains the gigantic remains of *Dinichthys* and *Aspidichthys*, is also the sediment of an open, though shallower sea; and the fishes which it contains must have inhabited relatively deep water, as we do not find them associated with any traces of shore-lines. In striking contrast with these facts, the Catskill fishes are buried in mechanical sediments, such as could only have accumulated immediately along the shore of the continent.

When now we examine the deposits which contain the fossil fishes of the Devonian in the Old World, we see (1) that nine-tenths of the whole number are enveloped in mechanical sediments—sandstones and shales—evidently shore deposits; (2) that the great Devon limestone of England—the deposit of the open Devonian sea of that country, and the homologue of our Corniferous limestone—has contributed almost nothing to the list of English fossil fishes; and (3) that the only one of our Corniferous fishes found abroad, *Macropetalichthys*, was obtained from the Devonian limestone of the Eifel. It will also be noticed that the sediments which compose the Catskill group are precisely like those that hold the same genera of fossil fishes in Scotland, England and Ireland.

From these facts it is easy to see that at least a part of the difference between the American and European Devonian faunæ is due to the difference in the physical conditions under which the fishes that have been collected lived. The American Devonian fishes have been mainly taken from deposits of the open sea, where they were naturally larger, and somewhat different zoologically from those which inhabited the bays and shore-lines of the European continent and islands. Where the circumstances were similar, we have similar deposits and similar fishes, as in the Upper Old Red and Catskill. These considerations will, I think, go far to explain the absence from the American strata of the smaller Crossopterygians, *Osteolepis*, *Dipterus*, *Diplopterus*, etc., and of the little Acanthodians, *Cheiracanthus*, *Diplacanthus*, *Climatius*, etc., all of which we may suppose were the inhabitants of rivers, lakes, estuaries and shore-lines. It should be remembered, in this connection, that all our living scaled Ganoids are the inhabitants of rivers and lakes; only one of the seven living genera, under any circumstances, entering salt water.

Differences in geological position must also be considered as contributing something to the differences of fauna that I have referred to. It

will be remembered that the group of Placoderms which are found in such abundance at the base of the Devonian in Scotland and England—*Pteraspis*, *Cephalaspis*, *Scaphaspis*, etc., all of which are wanting in America—began their existence in the Upper Silurian; occurring in the Lower and Upper Ludlow rocks, the Tilestones, or passage beds, and in the lower and middle portions of the Old Red Sandstone. Hence they belong to a geological horizon below any that has furnished fossil fishes in this country, and represent the fauna of an age anterior to that of the Corniferous limestone. We must therefore look for corresponding members of that fauna in our Helderberg and Oriskany, where as yet we have found no fishes. Since almost no fishes have been obtained from the Devonshire limestone, it will be seen that on the two sides of the Atlantic we have been collecting Devonian fishes for the most part from very different members of the series; and hence it is not surprising that our lists of genera and species are different.

The correspondence of the fauna of the Catskill and Upper Old Red Sandstone of the British Islands is associated not only with a correspondence in physical conditions—to which I have already called attention—but also in geological age. It is now known that the Old Red Sandstone of Caithness, Orkney, Cromarty, etc., which supplied the fish fauna so eloquently described by Hugh Miller, forms the central portion of the great mass of the Old Red Sandstone, and its characteristic fishes are *Pterichthys*, *Coccosteus*, *Asterolepis*, *Osteolepis*, *Dipterus*, *Diplopterus*, *Cheiracanthus*, *Diplacanthus*, *Cheirolepis*, etc. With these fishes no mollusks are found, but numbers of bivalve crustaceans of the genus *Estheria*. These latter fossils are almost universally found in the sediments of lakes, lagoons and bays, and confirm what has been said in regard to the circumstances under which the Old Red Sandstone fishes lived and died.

The upper portion of the Old Red Sandstone of England, Scotland and Ireland consists of a series of yellow and red sandstones, which reach up without sensible change to the Lower Carboniferous limestone. In these rocks are a different group of fishes from those below, and differing notably in the absence of the Placoderms of the lower series, and in the presence of several species of the great Crossopterygian genus *Holoptychius*. This genus begins in the famous fish-bearing strata of Dura Den, and runs up into beds which are unmistakably Carboniferous, though represented at different horizons by different species. It has troubled the English geologists much to draw any well-marked line, in the series to which I have referred, between the Devonian and the Carboniferous systems; but there are none who do not regard as Carboniferous at least

a portion of the yellow sandstones which underlie the Carboniferous limestone, and contain *Holoptychius* as a characteristic fossil. Hence it will be seen that in the Catskill of Pennsylvania we have strata which are not only lithologically similar to those which in Scotland and England lie at the top of the Devonian and base of the Carboniferous system, but that this similarity of mineralogical character and geological position is accompanied by a similarity of fauna.

The bearing of the facts that have been cited on a question somewhat discussed in another portion of this report, viz., the question as to where the division line between the Devonian and Carboniferous should be drawn, is obvious. From the fact that the Catskill has usually been referred to as the American representative of the Old Red Sandstone, and its fossil fishes are generically such as are characteristic of the Upper Devonian of Europe, it has been naturally reckoned to be the summit of the Devonian, and to prove the Devonian age of the underlying Chemung rocks. In opposition to this view, I have contended that though the Catskill be the *conventional* summit of the Devonian system, the great geological cycle which we call the Carboniferous age, and of which we have a record in the circle of deposits described in the geological portion of our report, really begins with the Portage sandstones, and thus that the Chemung and Catskill should be included in the Carboniferous.

FISHES OF THE CARBONIFEROUS SYSTEM.

The Carboniferous rocks have furnished a large number of fossil fishes, both in the Old World and the New. These exhibit considerable diversity of size and structure, according to the geological positions which they occupy in the system, and the local physical conditions in which they lived. For example, the open sea of the period from which was deposited the Carboniferous limestone had quite a different ichthyic fauna from that of the bays and lagoons of the Coal Measure epoch. These differences will be indicated in the notes which follow on the fishes of the different members of the great Carboniferous system.

Considered in its general aspects, the Carboniferous fish-fauna contrasts strongly with that of the Devonian, and equally so with the ichthyic fauna of the Mesozoic ages, which is so fully represented in the collections made from the Jurassic and Cretaceous strata. The most striking changes which took place in the fishes of the world, as the Carboniferous succeeded the Devonian age, may briefly be sketched as follows:

First. We discover that the great group of Placoderms, which gave character to the fauna of the Devonian, have entirely disappeared; and

the names of the genera *Pterichthys*, *Coccosteus*, *Asterolepis*, *Dinichthys*, etc., which have been so frequently repeated on the preceding pages, appear no more in all the records of geological history.

Second. The Elasmobranchs, which held a subordinate position in the Upper Silurian and Devonian seas, are greatly multiplied and increased in size in that of the Carboniferous age.

Third. The Acanthodians maintain in the Carboniferous the numerical importance they held at the close of the Devonian; as they are represented by numerous species, though of diminutive size, till near the close of the Palæozoic era, when they apparently disappear forever.

Fourth. The Crossopterygians, which, as represented by *Holoptychius*, etc., enter the Carboniferous age in full force, though having, even in the Coal Measures, some members of great size and power—like *Megalichthys*—rapidly diminish in the later portion of the Carboniferous age, and in the Permian and Mesozoic formations are represented by only a single known family, the *Cœlacanthini*.

Fifth. The *Lepidostidæ*, which are supposed to be represented in the Devonian by *Cheirolepis*, exhibited in the Carboniferous a large increase of numbers, both of genera and species, but all of small size; and it would seem that the different species of *Palæoniscus*, *Amblypterus*, *Eurylepis*, etc.—all glittering in enameled and highly ornamented scales and head-plates—peopled the bays, lakes and rivers of the Carboniferous continents in the same way that our Cyprinoid Teleosts (Chubs, Shiners, etc.), and indeed, as we may say, the Gar-pikes—the lineal descendants of the Carboniferous Ganoids—do at the present day.

Sixth. The singular family of the Pycnodonts, unknown in the Devonian fauna, begin with the Carboniferous, and running through all its epochs with increasing force, assuming still greater development in the Mesozoic ages, disappear early in the Tertiary, and have no living representatives.

Seventh. Among the groups wanting in the Carboniferous, we should mention the Teleosts, of which no representatives are found anterior to the Mesozoic ages; and of the higher and true Teleosts, none below the Chalk.

All traces of the lowest orders of the class of fishes—the *Pharyngobranchii* and *Marsipobranchii*—are wanting in the Carboniferous strata, and indeed in all other members of the geological series. As has been remarked elsewhere, this fact, so inconsistent with the views generally entertained of the progress of life on the globe, may perhaps be accounted for on the supposition that the soft and destructible tissues of these embryonic forms of fishes have entirely disappeared.

In all the lists of Carboniferous fishes yet made out, no Chimæroids appear. And it has been heretofore supposed that they began in the Jurassic, and had no existence on the globe at so early a date as the Carboniferous age. If we are right, however, in considering the species of *Rhynchodus* now described, as Chimæroids, the absence of all members of the order *Holocephali* from the Carboniferous rocks would be very remarkable. And this difficulty suggests the question whether some of the great number of Elasmobranchs of which the teeth and spines are found in the Carboniferous limestone, such as *Deltodus*, *Trigonodus*, etc., should not rather be considered Chimæroids than Cestracionts. As comparatively few of the many Elasmobranchs of the Carboniferous have been found in Ohio, this group of fossil fishes will be very imperfectly illustrated in our report. In the Geological Survey of Illinois, however, an immense collection of Carboniferous sharks has been made. Over one hundred species have been described by Mr. A. H. Worthen and the writer. In Vols. II. and IV. of the Report of the Illinois Survey, some illustrations of the fauna referred to are given, which will be found of interest in this connection.

The new element which is introduced into the fauna of the globe in the Carboniferous age—the *Amphibia*—furnishes an interesting subject for investigation and speculation, but one that need not be pursued here. The Amphibian fauna which we have discovered in the Coal Measures of Ohio (including more than twenty species), will be illustrated by Prof. Cope in another volume of our report. The question of the origin of this fauna, and its relation to the fishes by which it was accompanied and preceded, it is hoped will be fully discussed by him. I will only say here, in reference to this subject, that some of the Amphibians found in the Coal Measures seem to have so much in common with the Crossopterygian fishes, that the opinion prevails among our best zoologists that these forms have a genetic relationship.

FISHES OF THE WAVERLY.

As has been shown in the geological portion of this report, the Waverly series consists of the shore and off-shore deposits of the Carboniferous sea, which gradually encroached upon, and finally submerged, a large portion of the previously existing continent. The strata which compose this series are mainly formed of mechanical material, though containing locally considerable lime or carbonaceous matter, the latter apparently derived from marine plants. From the nature of these strata, and the circumstances under which they were deposited, the re-

mains of fishes are less abundant in them, as a general rule, than in the sediments of the open ocean, or of the lagoons in the coal marshes. Still, in some localities, the remains of fishes are quite abundant in the Waverly, and a thin band in the carbonaceous shale which underlies the "city ledge" of Southern Ohio and Northeastern Kentucky, is a genuine "fish-bed." The surfaces of the laminæ composing this band are sometimes thickly strown with the spines, teeth and dermal tubercles of sharks, and the scales and bones of *Palæoniscus*. The fishes of this horizon—which is near the base of the formation—consist of two species of *Ctenacanthus* (*Ct. formosus* and *Ct. furcicarinatus*), one species of *Orodus* (*O. variabilis*) and one of *Cladodus* (*C. Pattersoni*), all of which will be found described in other portions of this report. There is little doubt that some of the teeth and spines named above were associated as organs of the same fish. From the dismembered condition in which we find the remains of these cartilaginous fishes, it rarely happens that the spines, teeth and dermal tubercles are so associated that we can determine satisfactorily their relations. The companionship, however, of some of these fish remains, leads me to conjecture that the teeth called *Orodus variabilis* formed the dentition of the fish which carried the dorsal spine I have named *Ctenacanthus furcicarinatus*. In this formation and locality was discovered a unique specimen of a jaw of *Cladodus Pattersoni*, on which several hundred teeth occupy nearly their normal positions. This specimen will be figured and described elsewhere. I should also mention, in this connection, a remarkable shark's tail, found at Vanceburg, Kentucky, by Capt. Patterson, in the fish-bed before alluded to. This specimen, which is nearly a foot and a half long, shows the outline of the heterocercal tail of a shark which must have been eight or ten feet in length The vertebral column is seen to reach far into the upper lobe of the tail. The vertebræ have entirely disappeared, leaving a smooth band to mark the space they occupied. This is bordered on either side by the impressions of linear, pointed, apophysial bones, which were evidently much better ossified than the centra of the vertebræ. The lower lobe of the tail is formed by a number of *strong, ossified rays!* This shows that this Carboniferous shark—which I suppose to have been the same that had *Orodus* for his teeth, and wore *Ctenacanthus* as a dorsal spine—had a skeleton in some respects more fully ossified than most of the sharks of the present day.

The *Cleveland Shale*, a bituminous stratum twenty to sixty feet in thickness, holding in Northern Ohio the same position as that which in Southern Ohio includes the fish remains last described, every where contains traces of fishes. In general, these are small, rhomboidal, polished

scales, which belonged to a species of *Palæoniscus* of which no good specimens have as yet been obtained. At Bedford, Cuyahoga County, the Cleveland shale contains, with *Cladodus Pattersoni*, a small and highly ornamented species of *Orodus* and a small *Polyrhizodus*, both yet undescribed. The surfaces of the laminæ of the shale are locally covered with beautifully defined Conodonts—the little comb-like denticles over which there has been so much discussion by zoologists. These Conodonts will be figured and described in another volume of this report.

The *Bedford Shale*, which lies next above the black Cleveland shale last mentioned, has yielded, so far as I know, but a single fragment of a fish. In one of the calcareous bands which traverse this deposit on the banks of Black river below Elyria, I found a portion of the bone of a fish which must have been as large as *Dinichthys*. It was only a fragment when imbedded in the calcareous mud, which subsequently became the rock in which it was found. This fragment is rudely triangular in form, one side being arched, and this was evidently a part of the margin of the plate. It was originally quite solid and nearly an inch and a half in thickness. I do not recognize in this piece of bone any portion of the carapace of *Dinichthys*, or indeed of any other known fish. It is perhaps more likely that it was a part of the posterior extremity of the dentary bone of a species of *Dinichthys* or some other allied Placoderm. If this was its position, it belonged to a fish larger than any *Dinichthys* yet discovered. Although affording a very imperfect idea of the structure to which it belonged, this bone is of great interest and significance, inasmuch as it proves that very large fishes lived in the water from which the Bedford shale was deposited, and gives good cause to hope that, with careful search, this deposit, hitherto considered barren of fish remains, may be made to contribute some most interesting material to the known fauna of the Lower Carboniferous epoch.

The *Berea Grit*, being a coarse mechanical deposit, would seem to promise very little in the way of fossil fishes. And yet, while it is true that as a general rule it is barren of fossils of all kinds, at one locality, Chagrin Falls, the upper layers of the Berea are found to contain a large number of a distinct species of *Palæoniscus* (*P. Brainerdi*), of which, so far as I can learn, no traces have yet been discovered elsewhere. Among the fragments thrown out in working the quarries at Berea, I found a detached piece of bone several inches in diameter, which must have belonged to a large and as yet unknown fish. It is also reported that in the same quarries, some years since, a complete fish spine was obtained, and for a long time preserved. This specimen is now lost, but, from the description given me, I infer that it was a species of *Ctenacan-*

thus.* In the equivalent of the Berea my assistant, Mr. G. K. Gilbert, discovered, on Oil creek, Pennsylvania, the most remarkable accumulation of fish spines of which I have any knowledge. These were scattered over the surface of a block of sandstone which had become detached from the cliff, and their numbers may be inferred from the fact that more than a dozen spines are imbedded in that portion of the rock, less than two feet square, which Mr. Gilbert brought away with him. All these spines apparently belong to one species, *Ctenacanthus triangularis*, which will be found described on another page. In the same locality other layers of sandstone were covered thickly with the scales and teeth of fishes. Of these, the scales are those of *Palæoniscus*, perhaps *P. Brainerdi*. The teeth are those of Selachians, mainly *Helodus* and *Orodus*; among others *O. coniculus*, a common fossil of the Keokuk limestone in Illinois. I should also mention that in the very basal portion of the Berea sandstone at Berea, Mr. Hertzer found two species of *Cladodus*, both of which are as yet undescribed.

The *Cuyahoga Shale*, the uppermost member of the Waverly, has no where yielded any considerable number of the remains of fishes, and yet a few specimens of great interest have been obtained from it. At Berea a species of *Cladodus*, perhaps not distinct from *C. Pattersoni*, is found at the base of the Cuyahoga shale, immediately above the sandstone; and at Chagrin Falls, in precisely the same geological position, scales of *Palæoniscus* are thickly scattered among the *Lingulæ* with which the shale is crowded. In the upper part of the Cuyahoga shale, fish remains of much greater size and interest have been discovered. At Bagdad and Lodi, Medina County, we have obtained spines of two species of *Gyracanthus*, *G. Alleni*, and *G. compressus*. These spines have more than ordinary interest, from the fact that they belong to a genus which is characteristic of the Carboniferous rocks of Europe and Nova Scotia, but one that has never before been found within the limits of the United States. At Warren, Ohio, Mr. M. C. Read discovered in the upper part of the Cuyahoga shale a magnificent specimen of *Ctenacanthus formosus*, which has a length of fourteen inches.

It will be seen from the notices I have given of the fishes of the Waverly, that there can be no reasonable doubt of its Carboniferous age. Indeed, they practically decided this much-discussed question before the

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* Since the above paragraph was written, Mr. C. T. Blakesley, of Chagrin Falls, has found in his quarries worked in the Berea grit, a distinctly marked specimen of *Ctenacanthus formosus*, similar in size and form to that obtained by Mr. Read from the Cuyahoga shale, and mentioned in another paragraph.

molluscous fossils and stratigraphical relations had given their testimony in the case. With the combined evidence we may say that the proof amounts to a demonstration. It will also be noticed that *Cladodus Pattersoni* and *Ctenacanthus formosus*, running through the formation, with *Syringothyris typa*, *Orthis Michelini* and other mollusks, bind its subdivisions together into one whole.

FISHES OF THE SUB-CARBONIFEROUS LIMESTONE.

The Lower Carboniferous limestone is, in other States and countries, perhaps more prolific in the remains of fishes than any other formation. In Illinois, Iowa and Missouri, nearly a hundred species of the teeth of Selachians have been obtained from this formation, and the very similar fish remains described by Agassiz, Portlock and McCoy, from the Carboniferous limestone of Armagh, Ireland, are well known to geologists. The general character of this fauna has been already alluded to. Being an open-sea deposit, the Carboniferous limestone would naturally contain a different group of fishes from those entombed in the mechanical sediments that accumulated along the shoals and shores of this sea; hence the fishes of the Carboniferous limestone are quite different from those of the Waverly, even where the beds are cotemporaneous. We naturally find, among the fishes of the limestone, the teeth and spines of sharks; in the Waverly, the scales of the shore-loving Lepidoganoids. It is somewhat remarkable that while the remains of sharks are so plentiful in the limestone, we have as yet found among them no traces of fishes which correspond to *Macropetalichthys* and *Onychodus*, the great, omnipresent Ganoids of the Devonian sea. We must, therefore, conclude that while the Placoderms and Crossopterygians were the monarchs of the *Devonian* sea, and the Elasmobranchs were then much fewer in number and smaller in size than they, when the submergence took place which buried so much of our continent beneath the Carboniferous sea, and spread its calcareous sediment over the area where now we find the Carboniferous limestone, in the lapse of thousands, perhaps millions of years, the fauna of the globe had been revolutionized. In this latter age the Elasmobranchs had become both relatively and absolutely more numerous and powerful; the Placoderms were nearly extinct; and the Ganoids of all groups had pretty much abandoned the sea, but in various forms thronged the quiet waters of bays and rivers. By what influence this difference of destiny was brought about we can, as yet, only conjecture; but the contrast in the life-histories of these great groups of fishes is very striking. So far as we know, they began almost simultaneously, but for a long time—all through the

Upper Silurian and Devonian ages in fact—the Ganoids* were the ruling dynasty. But somehow and somewhere in the long interval between the Devonian and Carboniferous seas the sceptre passed from them. They were elsewhere still powerful, however; for *Dinichthys*, or some congener, lorded it over the weaker tribes along the shores of the Lower Carboniferous continent, and *Megalichthys* and *Rhizodus* disputed with *Ctenacanthus* and *Edestus* the rule of the bays and lagoons during the Coal Measure epoch. In the Mesozoic, too, the Ganoids were respectable in numbers, and, when we think of the great *Lepidotus*, six feet in length, we may say, in size; but they were then the ruled, and not the rulers. Most of them were pretty well defended, but inoffensive creatures, and they were the natural prey of the predaceous and powerful Hybodonts, whose spines and teeth so thickly strew the bottom of the Jurassic sea. In later times the preponderance of the Elasmobranchs has grown more and more conspicuous; for, while the Ganoids have dwindled to a mere hand-full, the sharks have become the tyrants of the ocean. The Selachians now number hundreds of species; and the basking shark attains a length of thirty feet. But even this monster shrinks into insignficance when compared with the great *Carcharodon* of the Tertiary, whose length could not have been less than fifty feet, and whose lancet-shaped teeth are as large as one's hand.

The exposures of the Carboniferous limestone in Ohio are few, and they have never yet been carefully searched for fish remains. It is to be expected, however, that some fishes will be obtained from them, and these are likely to be those found in the upper or Chester subdivision, the only portion of the great, western limestone mass that is represented in our State.

FISHES OF THE COAL MEASURES.

The Conglomerate, so far as I know, has yielded no fishes, either in our own State or elsewhere; but the limestones of the Coal Measures, and especially the Cannel coals (which were formed from the accumulation of carbonaceous mud in the lagoons of the coal marshes), have furnished quite a long list of genera and species. Here we find repeated, though on a small scale, the differences of fauna to which I have already alluded. In the limestones, which mark periods of submergence, and the wide spread of the waters of the ocean over the coal marshes, there are few traces of the scaled Ganoids; but many teeth of the peculiar sharks of the period (*Petalodus*, *Cladodus*, *Ctenoptychius*, etc.); while in the sediments of the lagoons are great numbers of the smaller Ganoids, *Palæoniscus*, *Amblypterus*, *Eurylepis* and *Cœlacanthus*. Here, too, we find

*Ganoids of Agassiz, including Placoderms and Cephalaspids.

the teeth and spines of that peculiar Elasmobranch, *Diplodus*, in which the teeth are like a pair of minute horns, and the serrated spine was set immediately back of the head. The most striking features in the ichthyic fauna of the Coal Measures are, however, the great spines of the different species of *Ctenacanthus* and *Edestus*. Of these, *Ctenacanthus*, though running through several formations, seems to have attained its greatest development in the Coal Measure epoch. *Edestus* constitutes the most peculiar organ of defense among all the tribes of fishes. It seems to have been a dorsal spine, but was sometimes a foot and a half in length, three inches deep, composed of solid bone, and having the upper margin set with triangular, crenulated, enameled denticles, of which the largest were an inch and a half in length. No remains of this remarkable genus have yet been found in Ohio, but several species described by Prof. Leidy and myself have been obtained from the Coal Measures of Indiana, Illinois and Arkansas. For further description of *Edestus*, the reader is referred to page 286.

As the spines of *Ctenacanthus* were sometimes scarcely less formidable than those of *Edestus*, we must conclude that the sharks which bore these weapons were the rulers of the waters during the Coal Measure epoch. It is true that, before their reign was ended, the pioneers of a new dynasty, and one destined in the next age to completely supplant them, made their appearance on the stage. The Amphibians of the Coal Measure epoch were, however, for the most part small and weak; and it was only in certain of the steaming pools and lagoons of the coal marshes that carnivorous salamanders enjoyed a brief and local rule.

In the descriptive portion of this volume, quite a number of species of fossil fishes from the Coal Measures of Ohio are figured and described. A large part of these are from a single locality, which has already become somewhat celebrated for the number and interest of the fossil forms it has furnished. I refer to Linton, on the Ohio river, at the mouth of Yellow creek. The fossils are found there in a thin stratum of cannel which underlies a thick seam of bituminous coal, that we have called Number 6, because it is the sixth workable seam from the base of the productive Coal Measures. Already about twenty species of fishes have been obtained from this deposit, and at least as many Amphibians; and all found here for the first time, although two or three species have since been met with in other localities, in this or adjoining States. On tracing Coal-seam No. 6, in various directions from Linton, the cannel at its base is found to thin out and soon disappear. We learn, from a careful study of the deposit, that there was in this locality at the time when the coal was forming, an open lagoon, densely populated with fishes and salaman-

ders; and that after a time this lagoon was choked up with growing vegetation; and peat (which afterward changed to cubical coal) succeeded to the carbonaceous mud (now cannel) that had previously accumulated at the bottom of the water. The fishes of this pool were mostly small, tile-scaled Ganoids, belonging to the genus *Eurylepis*. Though here extremely abundant, they have not been found elsewhere. I have enumerated nine species of this genus, but possibly some of them should be considered as mere varieties. There were also in this lagoon two, or perhaps three, species of *Cœlacanthus* (one of which is so closely allied to *C. lepturus* of the Coal Measures of Europe, that they should perhaps not be separated), and yet this genus has been no where else recognized on the American continent. There are also found here the thin scales, from one to two inches in diameter, some ornamented and some plain, and also the lance-head teeth of *Rhizodus*, and the teeth and spines of *Diplodus*. On the whole, this must be looked upon as one of the most interesting localities of vertebrate fossils known on this continent; and it is even doubtful whether *any* other equals it in the number of new species or in their zoological and geological interest.

The following is a list of the fossil fishes which have, up to the present time, been found at Linton:

Cœlacanthus robustus ..... Newb.
C. elegans ..... "
C. ornatus ..... "
Palæoniscus peltigerus ..... "
Eurylepis tuberculatus ..... "
E. corrugatus ..... "
E. ovoideus ..... "
E. insculptus ..... "
E. ornatissimus ..... "
E. granulatus ..... "
E. minimus ..... "
E. striolatus ..... "
E. lineatus ..... "
Rhizodus angustus ..... "
R. lancifer ..... "
R. quadratus ..... "
Orthacanthus arcuatus ..... "
Compsacanthus lævis ..... "
Diplodus compressus ..... "
D. latus ..... "
D. gracilis ..... "

A few other localities in the Coal Measures of Ohio deserve notice for the remains of fishes which have been obtained from them. In the can-

nel coal of Canfield, Mahoning County, a single, nearly complete specimen of *Palæoniscus peltigerus*, N., was found in a wonderful state of preservation—having not only all the scales in place, but the expanded fins nearly as perfect as in life. This species has been met with in several other places in the country, and, though much less common at Linton than *Eurylepis*, seems to have been more widely disseminated.

In the black shale over Coal No. 5, at Mineral Point, Tuscarawas County, I found a large number of scales of *Megalichthys*, the only case in which this genus has been recognized on this continent. Higher up in the series a well-marked fish-bed occurs in the Barren Coal Measures. This is the limestone band which has been called by Prof. Stevenson the Crinoidal limestone; by Prof. Andrews it is styled the Ames limestone. It is about 140 to 150 feet below the Pittsburg Coal seam (No. 8). From this limestone I have obtained in several localities *Petalodus Allegheniensis*, Leidy, and apparently a new species of *Ctenoptychius*. Detached scales of fishes have been found in the limestones of the Upper Coal Measures, but none that are sufficiently perfect for description.

To give completeness to this review, I ought, perhaps, to mention a few "extra-limital" Carboniferous fishes. I have referred incidentally to the spines of *Edestus* found in the Coal Measures of some of the States west of Ohio. Of this remarkable genus, three species are now known. *E. vorax*, Leidy, the largest of the group, is described in the Jour. Acad. Nat. Sci., Phila., 2d Ser., Vol. III., p. 159, Pl. 15. *E. Heinrichi*, N. and W., is from the coal of Belleville, Ill. This latter species is described in the report of the Geological Survey of Illinois, Vol. IV., p. 350, Pl. 1 *a*, 1 *b*. Since the publication of this description, I have received from Vermillion County, Ind., through the kindness of Prof. F. H. Bradley, a small and evidently young specimen of *E. Heinrichi*, which shows the superior extremity of the spine, and illustrates in a very interesting manner its mode of growth. This specimen will be figured and described in another volume of our report, where the structure and relations of this remarkable genus will be more fully discussed than they have heretofore been.

The third species of *Edestus*, but first in date of discovery, is *E. minor*, N., of which the best specimen known is in the cabinet of Amherst College. This is described and figured in the report of the Geological Survey of Illinois, Vol. II., p. 84, Pl. IV., fig. 24; Vol. IV., p. 351, Pl. I., fig. 2. It is also badly figured and imperfectly described in the proceedings of the ninth meeting of the American Association, and in Owen's Palæontology. It is a striking fact that all the specimens of *Edestus* known were found in bituminous shale associated with coal seams, or in cannel coal; and we may infer from this that the fish, of which this was the

defensive spine, was the inhabitant of the lagoons of fresh ? water which were scattered over the great coal marshes.

In the interesting group of fossils contained in the nodules of iron ore found in the Coal Measures at Morris, Grundy County, Illinois, are a number of fishes which have not yet been met with elsewhere, but which may be looked for in other localities at the same horizon. Among these are a small *Palæoniscus*, and, what are of much greater interest, species of *Amblypterus* and *Platysomus*, fishes sufficiently common in the Coal Measures of Europe, but not elsewhere known in this country. Both of these fishes, *Amblypterus macropterus*, Ag., and *Platysomus circularis*, N. and W., are described in the report of the Geological Survey of Illinois, Vol. IV., p. 347. The very close resemblance or specific identity of this species of *Amblypterus* and the most common *Cœlacanthus* of Ohio, (*C. elegans*) with the most abundant species of these genera in Europe, affords another and interesting illustration of the remarkable unity which has been discovered in the fauna and flora of the Coal Measures of Europe and America. The *Platysomus* mentioned above is of additional interest, as it is the first of the Palæozoic Pycnodonts found in America. To this, however, I can add another in the dentition of a much larger fish found by Mr. G. K. Gilbert in the Sub-Carboniferous limestone of Arizona.

In New Brunswick and Nova Scotia the Carboniferous rocks have yielded quite a large number of fish remains, most of which have been described by Prof. Dawson in his charming "Acadian Geology." *Ctenoptychius*, *Ctenodus*, *Rhizodus*, *Diplodus* and *Gyracanthus* are enumerated and figured by Prof. Dawson (Acadian Geology, p. 210). In the strata which contain the Albertite, at Hillsborough, New Brunswick, specimens of *Palæoniscus* are of frequent occurrence. A number of species have been described by Dr. Chas. T. Jackson, of Boston, in a special paper descriptive of the Albertite and its associated fossils.

The reader is also referred to the following papers for interesting information in regard to our fossil fishes:

"Descriptions of the remains of fishes from the Carboniferous limestone of Illinois and Missouri," by Joseph Leidy, M.D., Trans. Amer. Philos. Soc., Vol. XI., p. 87.

"Descriptions of some remains of fishes from the Carboniferous and Devonian formations of the United States," by Joseph Leidy, M.D., Jour. Acad. Nat. Sci., Phila., 2d Ser., Vol. III., p. 159, Pl. 15, 16, 17.

Also, notices of some Carboniferous fishes of Alabama, by Prof. Toumey, contained in the Second Report on the Geology of Alabama.

ORIGIN OF OUR ICHTHYIC FAUNA.

The following brief summary comprises all that we can at present safely say in regard to the derivation of our fossil fishes. As has been repeatedly stated on the foregoing pages, the oldest remains of fishes yet found in the world are in the Upper Silurian rocks of Europe. These are Placoderms and Elasmobranchs, generally of small size, but existing in large variety, and exhibiting a structure so elaborate and highly organized, that by some zoologists they are thought to rank among the highest in the class of Fishes. By others they are ranked lower; but by none is an embryonic or rudimentary character assigned to them. These earlier fishes were the cotemporaries of large and powerful Cephalopods, and of Crustaceans (*Pterygotus*, etc.) much larger than any now living. With the latter the Placoderms have been compared, from the fact that defensive shields were worn by both. But they were as different in organization as *Scaphirhyncus* and *Limulus*, and we are, up to the present time, without links which connect them, or any proof of relationship or derivation.

In America, the first remains of fishes are found in the Corniferous limestone; but here they appear in great force, consisting of several genera and species, some of which attain gigantic dimensions. Of the origin of this fauna we now know nothing, and probably never shall know much. It will be remembered by those who have read the geological portion of this volume, that I have ascribed the several circles of deposition which form our geological systems to successive invasions of the land by the sea. The first submergence of the old Eozoic continent resulted in the deposition of the great limestone group of the Lower Silurian. In these sediments we have the remains of probably all the forms of life that inhabited this sea, except such as were without hard parts; and, as we have seen, the ocean of that period teemed with protozoans, radiates, mollusks and crustaceans, but, so far as we yet know, was without vertebrates. After standing for perhaps millions of years over what is now North America, the Lower Silurian sea was withdrawn, and was succeeded by a land surface on which no strata were deposited. After the lapse of thousands or millions of years, this land was again submerged—the sea reaching nearly as far as before. In the advance, continuance and retreat of this second submergence, the series of strata we call Upper Silurian were deposited. Of these, the Clinton, Niagara and Helderberg limestones are made up of organic materials derived from the structures of the animals that inhabited the Upper Silurian sea. In this great calcareous mass we have a record of the marine life

of the age, so far as any record has been left of it. As before stated, even here we have in America as yet found no traces of Vertebrates. When, however, the waters retreated to the oceanic basins that have been always sea, and after, perhaps, other millions of years, came back again in the Devonian submergence, we find them inhabited by a horde of ichthyic monsters, some of which could hardly have been less formidable than the sanguinary and dreaded sharks of the present day. They were imposing, not only from their size, but from the completeness of their armor, both for attack and defense. Whether any of them had ossified vertebræ or not, remains to be determined; but that a larger part of their structure was composed of true bone than in any fishes of the present period, can be easily shown. The origin and earlier history of this great ichthyic fauna is perhaps written in the unexplored depths of the oceanic basins from which it came; but to us it "sprang, like Minerva, full-armed from the head of Jove." With the Devonian seas in their retreat, departed all the group of great bucklered fishes, never more to return. In the sea of the Carboniferous age, sharks abounded in great numbers, and they seem to have reigned at this period as monarchs of the ocean world. Along the shores, and in the lagoons and rivers of the Coal Measure epoch, a multitude of Ganoids abounded, mostly small, glittering in polished scale-armor, or having all their scales and bones elaborately chased and ornamented. In the same strata and localities, another and higher class of vertebrates, the Amphibians, have left abundant remains. Many of these were aquatic, carnivorous salamanders, not unlike in form and habit the *Menopoma* of our streams and lakes, but far exceeding that in dimensions. Others were slender and snake-like, almost without limbs. The Ganoids shade so gradually into these Amphibians, that it is impossible to draw any well-defined line between them. And there is little doubt that a connected chain of being leads from the Ganoids through the Amphibians up to the true Reptiles.

With the retreat of the Carboniferous sea, most of the interval between the Mississippi and the Atlantic was left dry land, and has never since been submerged. On this land, or the lakes and rivers of the Canadian continent, which has remained as land since a period anterior to the Silurian age, the Ganoids of the Coal period have continued to exist, and in our *Lepidosteus* and *Amia* we probably have the lineal descendants of *Palæoniscus*, *Cœlacanthus*, etc., of the Carboniferous age.

DESCRIPTIONS OF

FISHES OF THE DEVONIAN SYSTEM.

GANOIDEI.

CHONDROSTEIDÆ?

Genus MACROPETALICHTHYS, N. and O.

The generic characters of *Macropetalichthys* may be thus described:

"Ganoid fishes of large size; cranium composed of large, polygonal plates, united by double sutures which are nearly concealed by the tubercled, enameled surface; tuberculation stellate; surface ornamented by double rows of pores and single thread lines, forming a pattern which does not correspond with the plates below; eye orbits conspicuous, inclosed in the orbital (Frontal?) plates; nasal plate (Ethmoid?) wedge-shaped, the apex turned backward, and reaching to the center of the cranium; occipital plate (Supra-occipital) oblong, emarginate behind, prolonged anteriorly into a point which meets the opposing point of the nasal plate; teeth and scales unknown; probably wanting."

The crania of *Macropetalichthys* constitute the most striking of the remains of fishes found in the Corniferous limestone, as they are composed of large geometrical plates, and are sometimes fifteen inches in length. They have attracted the attention of all quarrymen who work in this rock, and by them are usually regarded as carapaces of turtles. They are, however, plainly the crania of large Ganoid fishes, and are the more interesting as they occur in the Old World as well as in America, and serve as another connecting link between the Devonian limestones of the Eifel and those of our own country.

The name now borne by this fish was conferred by Drs. Norwood and Owen. The specimen described by these gentlemen was found in the Corniferous limestone near Madison, Indiana. When it came into their hands it was much broken. As a consequence, the description based upon it was very imperfect, in some respects erroneous, and, as will be seen, was sure to mislead any one who might discover other representatives of the genus to which it belonged. Dr. Owen described his fish as "being entirely destitute of a tubercled dermal surface; without distinct

eye-orbits; provided with two spinous appendages, or horns, and having the escutcheons covered with angular, irregular, rhomboidal, enameled, but minute scales"—all of which is entirely at variance with the characteristics of the crania which I have examined, derived from the same formation, and which, judging from a plaster cast of the original which I have seen, are generically identical with that described by Dr. Owen.*

In the *Jahrbuch fur Mineralogie*, 1846, p. 596, Hermann von Meyer gives a brief notice of the discovery of what he regards as a species of *Placothorax* from the "transition limestones" of the Eifel. This fossil he named *Placothorax Agassizii;* and in the *Palæontographica* (Vol. I., p. 102, t. XII.) he gives a figure and detailed description of it.

In Von Meyer's specimen of this fish the tubercled, dermal surface is nowhere exhibited, and no characters are derived from it; his diagnosis being based on the cast of the under surfaces of the bony plates—the plates themselves having mostly disappeared.

Of these plates, the impressions of portions of six are shown. They were united by double sutures, and consist of two on the median line, and two pairs of lateral plates separated by these. Of the central plates, one is oblong, rounded at what he supposed to be its anterior extremity, and terminates "posteriorly" in a central, salient angle, which is met by the more acute "anterior" angle of a narrow, cuneiform plate, the second and "posterior" of the central plates. On either side of this narrow plate lies a broad, trapezoidal plate, the two forming a pair, in which are set the eye-orbits, "far back from the snout."

"Anterior" to the orbital plates, and joining laterally the "nasal" plate first mentioned, are two small, triangular plates, of which the exterior margins combine with the "anterior" border of the "nasal" plate to give a rounded outline to the "snout."

Dr. Giebel (*Fauna der Vorwelt*, I. 3, p. 265), and Pictet (*Palcontologie*, II., p. 224), both of whom notice this fish, accept without question Von Meyer's name and description, and with him place it among the *Cephalaspidæ*. By comparing Von Meyer's figure with that now given (Pl. 24), any one will see at a glance that his fish is at least generically identical with our *Macropetalichthys*, and that he has mistaken the relations of the parts of his fossil, and has described as the nasal extremity of the head what is really the occiput, and the occipital plate as the nasal; in his specimen the anterior (and not, as he says, the posterior) extremity being wanting, and the posterior portion folded under and unnaturally rounded.

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* American Journal of Science, 2d Series, Vol. I., p. 367 (1846).

The change of position of the head required by my specimens brings the eyes comparatively near the nose, and gives a symmetry and propriety to its appearance, the want of which is apparent in Von Meyer's figure.

That the "*Placothorax*" of Von Meyer (i. e., *Macropetalichthys*) is not generically identical with the *Placothorax* of Agassiz, is, I think, also certain.

The genus *Placothorax* was first established by Agassiz in 1845 (*Pois. Foss. Vieux Gres Rouge*, p. 134, t. 30, figs. 20–23) to receive a fossil, at that time unique, from the Devonian rocks near Elgin, in Scotland. This was but a fragment, and only a drawing of that was submitted to Agassiz. He, however, pronounced it a portion of the cephalo-thoracic buckler of a fish belonging to a new genus, and to his family of *Cephalaspides*.

In *Placothorax*, Agass., the exterior surfaces of the plates are covered with tubercles set in rows—on the superior plates parallel to their borders, on the lateral plates in longitudinal lines parallel with the axis of the fish—and the sutures of the plates are externally conspicuous.

In *Macropetalichthys* (*Placothorax*, V. Meyer), the mosaic pattern formed by the plates is quite different; the tubercles of the dermal surface—so characteristic, in their form and arrangement, of the different genera in which they are found—are stellate, as in *Asterolepis*, and are either irregularly scattered over the surface, or set in short lines radiating from different centers; and the sutures are, for the most part, concealed by them.

In these characters, and in others, the *Placothorax* of Von Meyer (*Macropetalichthys*) differs from the *Placothorax* of Agassiz, and should therefore be considered as a distinct genus.*

Of *Macropetalichthys* there are now enumerated four species, viz: *M. Sullivanti*, Newb.; *M. Agassizii*, Von Meyer; *M. Manni*, Newb.; *M. rapheidolabis*, N. and O. It is, however, possible that the last two are identical with the two former; but just what Norwood and Owen's species is, we shall probably never know, as their description does not tell us, and the original specimen has been lost sight of; neither do Von Meyer's descriptions nor figures furnish the means of making an accurate comparison with our American fossils.

In the earlier notices of this genus, teeth which were frequently found associated with the crania of *Macropetalichthys* were conjecturally assigned to this fish; but it is now known that these teeth belonged to a different Ganoid, often met with in the Corniferous limestone (*Onychodus*). Though some hundreds of the crania of *Macropetalichthys*, in better or

* *Placothorax*, Agass., seems to me more likely to prove to be the arm (pectoral organ) of *Pterichthys*, than the buckler of any fish.

worse preservation, have been obtained, no teeth have been found connected with any of them; nor have any teeth been so associated with them as to render it probable that they formed the dentition of this fish. I am, therefore, led to believe that, like the Sturgeon, *Macropetalichthys* was toothless. I have two specimens which show the under side of the head, and are so fractured that what represents the head may be lifted out, exposing the under surface of the cranial plates. In these specimens the outlines of the jugular plates are shown, and anterior to them an undulated surface, apparently formed by a smooth, leathery integument, as in the Sturgeon, but no traces of teeth are anywhere visible.

Several specimens which I have seen exhibit casts of the central cavity of the skull, and prove that the volume of the brain was considerable. It occupied all the space under the Supra-occipital plate, and in large specimens was fully an inch in depth. The brain terminated in front and rear in two rounded lobes which have been sometimes mistaken for condyles.

The homologies of the skull of *Macropetalichthys* have not been fully made out. I give below a diagram showing the principal plates, but it is evident that not all are shown here. The edges of the lateral plates so overlap that it is difficult to trace the outlines of the smaller ones. This will doubtless be done, however, as more complete specimens are procured.

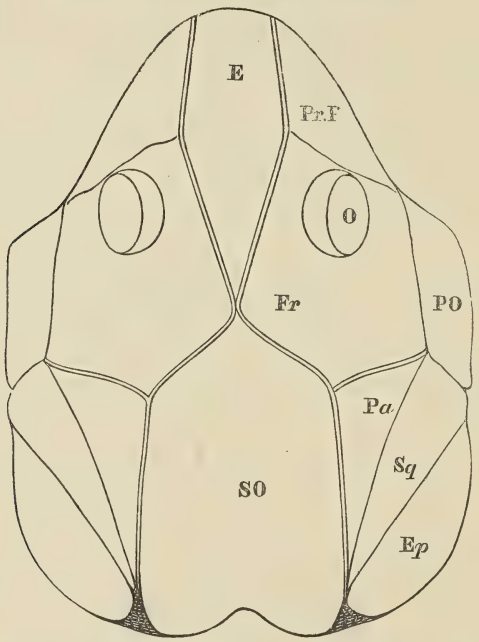
On Plate 24 the under surfaces of the cranial plates of *Macropetalichthys* are distinctly shown. From such a view it will be seen that there is very little overlapping of the margins, and that they do not unite, as do the bones of the cranium in most fossil and living fishes, by squamosal sutures, but by the direct contact of the edges. The union between the plates was, however, very close and firm, as we rarely find them disarticulated. In this respect *Macropetalichthys* offers a strong contrast to *Onychodus*, in which the numerous plates of which the cranium was composed are almost always found disconnected and scattered about in the rock which incloses them.

It will also be noticed that the plates of the cranium of *Macropetalichthys* are quite thick and continuous, with no lacunæ or cartilaginous spaces.

The zoological relations of *Macropetalichthys* can hardly be said to be determined by the remains yet found; but from the points which have been mentioned in the structure of the head, I am inclined to connect it with the Chondrosteans. The system of cranial plates in *Macropetalichthys* is simpler than in *Accipenser*, but the homologies of the more important ones seem to me to be quite plain. The character of the under surface

of the head is altogether sturgeon-like, and it is quite certain that the general plan of structure was the same in both. Prof. Huxley is inclined to connect the Cephalaspids, *Cephalaspis*, *Pteraspis*, etc., with the Chondrosteans as represented by *Scaphirhynchus* and *Spatularia*. If this relationship shall be proved to exist, we may very well conclude that *Macropetalichthys* is one link in the chain, and *Chondrosteus* of the Jurassic is another.

CRANIAL PLATES OF MACROPETALICHTHYS.



E. Ethmoid. Pr. F. Pre-frontal. Fr. Frontal. O. Orbital.
S. O. Supra-occipital. Pa. Parietal? Sq. Sqamosal? Ep. Epiotic?
P. O. Post-orbital.

Macropetalichthys Sullivanti, Newb.

Plate 24, Plate 25, Figs. 1, 1*a*.

Agassichthys Sullivanti, N.; Bulletin National Institute, 1857, p. 3.
Macropetalichthys Sullivanti, N.; Amer. Jour. Sci., 2d Series, Vol. XXIV., 1862, p. 75.

As crania of this fish have formed the basis of the generic description which I have given, comparatively little need be said in regard to the characteristics of the species. Among the specimens which have been under my observation, a great diversity in size has been noticeable, and so much variety in the details of structure, that I was at one time led to

conclude that we had in the Corniferous limestone of Ohio the representatives of two species of *Macropetalichthys*. In the paper read before the National Institute, cited above, two species were described, *M. Sullivanti* and *M. Manni*, the former including the larger and relatively broader crania—from 10 to 16 inches in length—with plates bounded by straight lines, and hence having a more geometrical appearance. The smaller crania—from 6 to 9 inches in length—having a narrower nasal plate, and the outlines of the frontals and supra-occipital gracefully curved, were set off in a species named in honor of the late Dr. Mann, an indefatigable and successful collector of Corniferous fossils of New Milford, Delaware County. After an examination of a very much larger amount of material than I had seen when these descriptions were written, I find it difficult to maintain the distinction between the species described, and am disposed to consider the differences which they exhibit as probably due to age or sex. Further observation may prove these forms to be specifically distinct; but for the present it is perhaps wiser to consider all of our specimens as varieties of *M. Sullivanti*. It would be very strange, however, if only one species of this remarkably distinct genus were found; and it is altogether probable that in the future, collections made from the Corniferous limestone in other States than Ohio, or from some other member of the Devonian system, will include forms that are more widely separated from the typical species than any that have come under my observation.

The specimen figured by Von Meyer is, so far as we know, the only one that has been discovered in Europe, and it very closely resembles those obtained in our State. The imperfect preservation of this specimen makes it impossible, however, to determine whether it is specifically identical with ours or not. The fact that one head of *Macropetalichthys* was found in the Devonian limestones of the Eifel, proves the genus to have had a very wide geographical range, and renders it almost certain that it will be met with in every other great exposure of the Devonian limestones. The specimen described by Drs. Norwood and Owen has been already referred to. It was too imperfect for accurate specific determination, and has since been lost, so that it can hardly be appealed to in a question of species. The cumbrous name given to it makes it rather fortunate than otherwise that it has been impossible to identify it, and we are therefore saved from the loss of time its frequent repetition would have occasioned.

The most important features in the structure and homologies of *M. Sullivanti* have been already given, but a few minor points remain to be noticed. The two plates which lie upon the median line of the cranium,

and which unite their salient angles at its center, I have considered the *Ethmoid* and *Supra-occipital*. The two polygonal lateral plates which inclose the eye-orbits seem to me to probably represent the *Frontals*, while the triangular plates anterior to the eyes should probably be considered as the *Pre-frontals*. The plates which form the posterior lateral portions of the skull are not distinctly separable, but they would seem to represent three, which I have fancied might be the *Parietal*, the *Squamosal* and the *Epiotic*. The exterior surface of the cranium is covered with densely-crowded, stellate tubercles, very well shown on Plate 25, Fig. 1. This sheet of tuberculated enamel, when entire, completely conceals the underlying bone. Along the principal sutures are lines of dots or pores which form a peculiar and tasteful ornamentation.

As mentioned in the generic description, several specimens of *Macropetalichthys* which have been found apparently show the under side of the head. In these a pair of plain and doubtless once thin plates occupy the posterior half of the under surface. These are united by a simple, straight, longitudinal suture. The anterior portion of the under surface is very imperfectly preserved. No osseous plates are visible here; nor are there any traces of teeth. It would seem, therefore, that this space had been occupied by soft tissues, which have disappeared in decay.

In the figure given on Plate 24, the under surface of the cranial plates of *Macropetalichthys Sullivanti* is well shown. The specimen is slightly injured by the breaking away of most of the Post-orbital plates, and by the splitting of the Ethmoid and Supra-occipital, the results of compression. In Plate 25, Fig. 1, we have a side view of the cranium of *Macropetalichthys*, showing the general character of the tuberculation of the external surface. In Fig. 1*a*, a series of the stellate tubercles which ornament the cranium are represented larger than natural, for the purpose of exhibiting their minute characters. Owing to the roughness of the tubercled surface it usually adheres to the matrix; and it is very rare to find so good an exhibition of it as that on the specimen figured.

CROSSOPTERYGIDÆ.

Genus ONYCHODUS, Newb.

Ganoid fishes of large size; cranium composed of a great number of bony plates covered with an enameled and tuberculated surface; tuberculation relatively fine, and formed by what may be compared to small

grooved cones, pressed down and adherent; jaws set with numerous conical, acute, more or less recurved teeth, of nearly uniform size; maxillary forming a low triangle, with much-produced, acute lateral angles; dentary bones posteriorly acute, where they are overlapped by the articular portions of the mandibles, long and narrow, curving upward to the symphysis, where they support an inter-mandibular arch of bone, to which was attached a single series of large, curved, conical teeth; teeth all smooth, covered with enamel, without basal plications; those of the maxillaries and mandibles implanted in sockets or anchylosed. The teeth of the median crest are seven in number, attached (by ligaments?) to an arched base, from which they radiate. They are much curved, often sigmoidally, have a circular section near the summit, are somewhat compressed below, and expand at base into several prominent roots or tuberosities. They have a central cavity extending nearly to the point, surrounded by dentine simple in structure; the external surface is formed by a layer of smooth and polished enamel.

The body of *Onychodus* was covered with imbricated scales, nearly circular in outline, and about an inch in diameter. The under surface of the scale is marked by fine concentric lines, as in *Holoptychius*. The exposed portion of the outer surface is ornamented with a tuberculation not unlike that of the plates, consisting of radiated but broken lines, and confused groups of minute, furrowed, appressed cones.

This genus was created by the writer many years ago, to receive certain conical, curved teeth found in considerable abundance in the Corniferous limestone. Figures and descriptions of these teeth are given in an article "On the Fossil Fishes of North America," published in the American Journal of Science, July, 1862, and they are also described in the Bulletin of the National Institute, Jan., 1857. As they are generally found detached, nothing was known until recently of their relation to any other fish remains found in the Corniferous limestone; and, as the most abundant cranium in that rock is that of *Macropetalichthys*, it was suggested that they formed part of the dentition of that fish. After a time, however, these teeth were found associated together, in rows of seven; an arrangement most like that of the teeth of Sharks. And as they seem to have been connected with their basal support by only ligamentous attachment, as the teeth of Sharks are attached to their jaws, this circumstance was regarded as confirmatory evidence of their Selachian character. It happened, however, in several instances, that plates of various forms, maxillaries and mandibles set with teeth, and numerous scales—each group evidently the fragments of a single individual—were found on slabs taken out of the quarries at Sandusky and Dela-

ware. Among these fragments there was almost invariably a single series of the teeth of *Onychodus*. How to establish a relationship between these teeth and the associated remains—which were those of a well-marked Ganoid fish—was for a long time a puzzle; but, by a fortunate discovery of Mr. Hertzer, the problem was at length solved. He found at Delaware a large mandible of *Onychodus*, to which the peculiar series of large teeth are attached in their normal position; that is, between the extremities of the mandibles, where they hold precisely the position of the median row in the dentition of a Shark. They are attached to a bony arch, from which they radiate. This is inserted in the symphysis of the jaw, supported by a shoulder on the internal face of the extremity of each mandible. So far as we yet know, there are no corresponding or interlocking teeth in the upper jaw; and hence it would seem that they armed the projecting extremity of the under jaw, just as the steel point arms the prow of a steam ram. We shall probably find more perfectly preserved specimens which will fully explain this apparently anomalous structure, and perhaps correct in some degree our conclusions in respect to it; but the specimens before me seem to establish beyond question the position of these teeth in the symphysis of the jaw.

The pattern formed by the numerous plates that compose the cranium of *Onychodus* is very complicated, and presents a puzzle not yet solved, for the cranium has never been found entire; and, indeed, it has only rarely happened that any two plates have been seen in connection. In this we have evidence of a want of solidification in the structure of the cranium, such as has not been noticed among any of the congeners of this fish. A number of the plates which compose the bony structure of the head can, however, be easily identified, such as the Opercula, Parietals, Frontals, etc.; but there are many others of which the homologies are not yet determined. The plates which belong to *Onychodus* are easily recognized by their peculiar tuberculation. This is relatively fine, and may be compared to a series of small, striated, appressed cones. In some instances these cones show but a single furrow by which they are notched at the summit; their height is two or three times the diameter, but each is laid over and adherent to the plate by its entire side. A similar tuberculation, though finer, covers the exposed portions of the maxillaries and mandibles.

In Ohio, *Onychodus* has, as yet, been met with only in the Corniferous limestone; but I have received from Delaware County, New York, numerous teeth, obtained from the Chemung, of a species of this genus, apparently different from that of the Corniferous.

In regard to the affinities of *Onychodus*, it is impossible now to speak

with absolute certainty, as all the specimens yet found have been in such a dismembered condition as to leave some important points of structure undetermined. There is little doubt, however, in my mind that it belonged to the *Crossopterygidæ*. The features which lead to this conclusion are the cycloidal, imbricated scales, having the exposed portion strongly, the covered portion more delicately, yet elegantly ornamented, much as in *Glyptolepis;* the spatulate or sandal-form Jugular plates, and the large rounded Opercula. Both these latter plates, as well as the Supra-temporals, resemble in form those of *Polypterus*. Hence we may infer that when the structure of *Onychodus* is more fully made out, we shall find that the paired fins are more or less lobate, the body fusiform, and the general appearance not unlike that of *Holoptychius* and *Glyptolepis*.

The peculiar dentition I have described is a point in the structure of *Onychodus* where it differs widely from the fishes with which I have associated it; but I have already shown how much the dentition varies among both recent and fossil fishes which, by other characters, are somewhat closely approximated. It may also be said that while on some large slabs of limestone we have found apparently most of the bony portions of *Onychodus*, among these were no plates, such as belong to the carapaces of the Placoderms; and we have, therefore, no evidence that it has any affinity with *Asterolepis*, *Coccosteus*, etc. The scales of *Onychodus* are not unlike those which were attributed by Hugh Miller to *Asterolepis;* but we now know that these scales really belong to *Glyptolepis*, and that, so far as known, the body of *Asterolepis* was without scales.

Onychodus sigmoides, Newb.

Plate 26, Figs. 1 to 5; Plate 27, Figs. 1, 2.

Onychodus sigmoides, N.; Bull. Nat. Inst., 1857, p. 5.

Fishes of large size; head at least one and a half feet long, composed of numerous angular and rounded plates, supported on a cartilaginous brain-box, and so imperfectly united that in the fossil state they are usually disconnected and scattered. Of the head-plates, the opercula are from 3 to 5 inches in diameter, nearly circular, but with a produced anterior angle. The maxillaries are triangular in outline, the anterior and posterior angles much produced, the lower margin nearly straight, and set with a large number of conical, pointed teeth. The dentary bone of the mandibles is often more than a foot in length, curved gently upward at its anterior extremity, which is rounded. Its posterior extremity is thin and flattened, running off to a point and edge, where it is overlaid by the

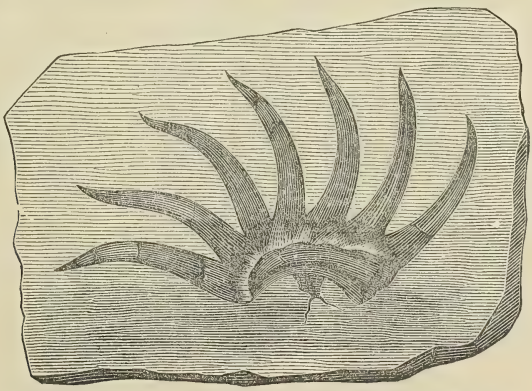
articular portion of the mandible. The upper margin of the dentary bone is thickly set with conical, pointed teeth. Embraced within the anterior extremities of the manibles is an arch of bone which supports a series of large, conical, sigmoidally curved teeth, seven in number, set vertically and projecting downward, forward and upward. These teeth show several prominent roots, which partially embrace the bases of the adjacent teeth. The exterior surfaces of the cephalic plates, and the exposed portions of the maxillaries and mandibles, are thickly set with small, enameled tubercles, which have the form of appressed, striated or sulcated cones. The body was covered with relatively thin, highly ornamented scales. These have a circular or elliptical outline; the under surface is smooth, or faintly marked with concentric lines, and often bears a central, elevated tubercle or ridge. The exterior surface shows an anterior semi-lunar space, occupying about half its area, where adjacent scales were superimposed. This space is comparatively smooth, but is delicately ornamented with radiating lines of pits. The posterior and exposed portion of each scale is roughened with appressed, striated tubercles, similar to those on the cephalic plates, and with branching, somewhat foliated ridges of enamel.

The foregoing description will be made more intelligible by referring to the accompanying plates (26 and 27). On Plate 26, Fig. 1, is represented a portion of the bony arch that occupies the symphysis of the under jaw, with three of the large teeth which are set upon it. This specimen was associated with the dentary bone represented on Plate 27, Fig. 1; and they, with a large number of plates of the head scattered about on the same block of limestone, evidently belonged to one fish. Fig. 2, Pl. 26, represents a single detached tooth of this central series found in another locality; Fig. 3, Pl. 26, a nearly complete series (wanting one) of these terminal teeth, from a small individual. Figs. 4 and 5, of the same plate, were drawn from a pair of dentary bones of a small individual, and probably the same with Fig. 3. Fig. 4*a* gives a cross-section of Fig. 4. On Plate 27, Fig. 1, is shown the inside of the dentary bone of a mature individual, but by no means the largest yet found. It will be noticed that the anterior extremity of the dentary bone is hollowed on the inside for the reception of the bony arch which carried the series of large teeth. In Fig. 2, of the same plate, is given an accurate representation of a dentary bone found at Delaware, with which the bony arch and its large teeth are seen nearly in the natural position. In this specimen the tuberculated character of the exposed portion of the dentary bone is well shown; and it will be also noticed that on the upper margin many small, pointed teeth are associated with the larger ones already

described—a feature common to many of the fossil Ganoids, and well shown in the living *Lepidosteus*. Fig. 2*a* represents the tuberculation of the jaw enlarged. Figs. 1*a*, 1*b*, and 1*c* show the scales of *Onychodus;* 1*a*, the internal surface, 1*b*, the external surface of a specimen, not well preserved, but the best at command when the figure was made. In more perfect scales the covered portion is seen to be marked with radiating lines of pits. 1*c* represents a portion of the exposed and most highly ornamented surface of a scale, much enlarged.

Figures of the cephalic plates of *Onychodus* are not given in the present volume, as their relationship has been but imperfectly made out; but I hope by the aid of new material to furnish hereafter more complete descriptions and better figures than would now be possible. The homologies of some of these plates have, however, been determined. The Jugulars, for example, are quite unmistakable. They are, in mature individuals, a foot in length by four inches wide, with a spatulate or sandal-shaped outline. The Opercula have been referred to. The Parietals and Supra-temporals have also been identified.

Up to the present time no remains of *Onychodus sigmoides* have been found in any other formation than the Corniferous limestone. Here, however, they are quite abundant, especially in the upper division (the Sandusky limestone), where, both at Sandusky and Delaware, certain layers contain such numbers of bones and teeth that they are designated by the quarrymen as *fish-beds*. The lower or Columbus subdivision of the Corniferous also contains the remains of *Onychodus*, locally, in considerable abundance. In the accompanying wood-cut is represented a complete series of the central teeth of *Onychodus*, intermediate in size between



CENTRAL TEETH OF ONYCHODUS SIGMOIDES, SLENDER FORM.

those represented on the plates. These I formerly supposed to be identical with a species found in the Chemung of New York; but I now have

reason to suppose that we have here only an immature specimen of *O. sigmoides*. In *O. Hopkinsii* of the Chemung, the teeth are apparently smaller than in *O. sigmoides*, and not often, if ever, sigmoidally curved.

It will be noticed that the larger and smaller series of teeth now figured (Figs. 1, 2, 3, Pl. 26, and wood-cut) differ very much, not only in length, but in strength, the larger teeth being relatively more robust. Some of the smaller teeth so frequently met with in the Corniferous limestone are also much more slender than others. These differences may be found to have a specific value, but it has seemed to me that they hardly afforded sufficient ground for a specific distinction.

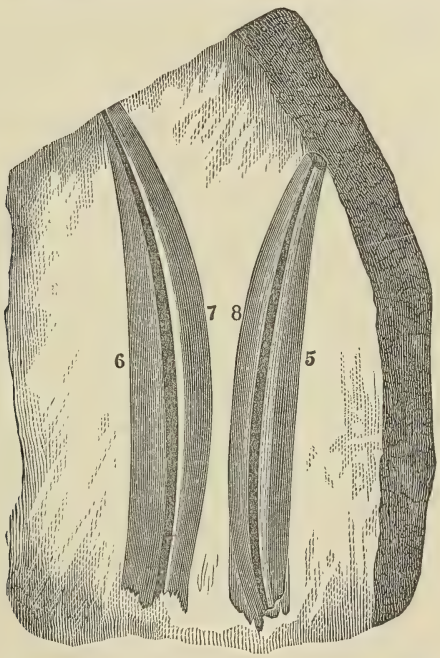
ELASMOBRANCHII.

Genus MACHÆRACANTHUS, Newb.

Spines often of large size, flattened, curved, ancipital, unsymmetrical (dextral and sinistral); edges and point generally acute; base somewhat narrowed, with a rough and irregular extremity; central cavity reaching nearly to the apex; external surface covered with a thin coating of enamel, in some species smooth, in others punctate and longitudinally striated; microscopic structure that of dense, ivory-like bone.

These spines are very characteristic of the horizon of the Corniferous limestone; having been found at this level in Indiana, various localities in Ohio, in New York, and at Gaspe, Canada. Though presenting some anomalous characters, among which the most remarkable is their want of symmetry (being rights and lefts), it is hardly possible they can be anything else than the defensive spines of fishes. Their dense, bony structure, enameled surface, and rough, irregular bases, would seem to prove that, like the fin-spines of many Sharks and Rays, they had been implanted in the integuments without articulation. Possibly they were the first rays of the pectoral fins, which would account for their being in pairs. In that case, it might be expected that the bases would exhibit some marks of their articulation to the pectoral arch. But as the fishes that bore them were undoubtedly cartilaginous, the insertion of pectoral spines—supposing they possessed them—would naturally somewhat resemble that of the dorsal spines. Many bony fishes, as *Arius*, etc., bear formidable dorsal and pectoral spines; but these always exhibit some indications of an articulation at their proximal extremities. In the Sharks, Chimæras and Rays, however, the dorsal spines are simply implanted in the integuments of the back, and each spine has a roughened and attenuated base, which is surrounded by a larger or smaller mass of

cartilage. Comparatively few cartilaginous fishes of the present epoch are provided with even dorsal spines; and none, so far as known, carry spines on the pectoral fins. In *Chimæra*, however, we have a peculiar spine placed anterior to each abdominal fin; and since, in the Mesozoic and Palæozoic ages, the Elasmobranchiate fishes were much more generally provided with spines, it is not too much to suppose that this tendency to the development of organs of defense should be exhibited in spines appended to the anterior paired fins. The tails of some of the Rays are armed with two closely approximated, serrated spines, and they distinctly show upper and lower surfaces; but both are set on the median line, and are straight. We should naturally expect, therefore, that the defensive spines worn by any cartilaginous fish on the dorso-median line would exhibit similar features. The spines of *Machæracanthus* are, however, distinctly rights and lefts; and in the unique specimen discovered by the late Prof. Hopkins, of Auburn, two spines, which apparently form a pair, are seen lying in the rock, probably nearly in their natural position. A wood-cut of this instructive specimen is given below. It was obtained from the Corniferous limestone at Auburn, New York.



PAIR OF SPINES OF MACHÆRACANTHUS PERACUTUS.

The polished and punctate surface of the spines of *Machæracanthus* gives them very much the appearance of some of the spinous appendages of Crustaceans, such as the telson of *Limulus;* but the dense bony

structure of the spines of *Machæracanthus* is very unlike anything I have seen among the articulates. Beside this, the exo-skeleton of Crustaceans is always jointed together, and the spinous appendages are distinctly articulated with the thoracic or abdominal segments. The spines of *Machæracanthus*, however, show no such articulation; and we are compelled to suppose, from the irregular bases which they present, that they were implanted in the integuments, or sunk in cartilage. From all the facts before me, I am led to conclude, therefore, that we see in *Machæracanthus* paired, defensive spines, which were formerly borne on the pectoral fins of some Elasmobranch fishes, of which all the other portions of the body have disappeared.

That the spines of *Machæracanthus* are homologous with the very peculiar spines which are set anterior to the abdominal fins in *Chimæra* seems scarcely possible, from the very great difference of form and size which they exhibit. When we remember that some of the spines of *Machæracanthus* are more than a foot and a half in length, double-edged and very sharp, we can hardly avoid the conclusion that they were used as weapons of attack or defense, and that they constituted most formidable and efficient ones.

Machæracanthus major, Newb.

Plate 25, Fig. 2.

Machæracanthus major, N.; Bull. Nat. Inst., 1857, p. 6.

Spine large and strong; length, 12 to 20 inches; greatest breadth, $1\frac{1}{2}$ inches; wing of concave border widest; point moderately acute; base narrowed and compressed, with a rough and irregular termination; upper (?) surface lightly striated longitudinally, central axis projecting in an imperfectly rounded ridge, $\frac{1}{2}$ inch wide, elevated $\frac{3}{16}$ inch above the wings; under (?) surface of central axis marked by about 10 distinct, longitudinal carinations; axis, $\frac{5}{8}$ inch wide, flattened, obliquely angled at sides, rising $\frac{1}{4}$ inch above the wings; base unequally sloped off where it was set obliquely into the integuments. At this point the carinations of the upper part become obsolete; sides of axis, above and below, punctate.

Formation and Locality: Corniferous limestone; Columbus, Delaware and Sandusky, Ohio.

Machæracanthus peracutus, Newb.

Plate 29, Fig. 6.

Machæracanthus peracutus, N ; Bull. Nat. Inst., *loc. cit.*

Spines 5 to 6 inches in length, 7 to 8 lines wide; point and edges very sharp; wings nearly equal; central axis on the upper surface forming a sharp and narrowed carination; below, a higher but more rounded ridge. This is perhaps the species most common in Ohio. It will be recognized by its small size, the acuteness of its point and edges, and by the angular ridge of the median line above and below. This is the species referred to in the generic description, and that which furnished the figures employed there to show the paired character of these spines. The average size and appearance are well shown in the illustration cited above.

Formation and Locality: Corniferous limestone; Delaware and Sandusky, Ohio.

Machæracanthus sulcatus, Newb.

Machæracanthus sulcatus, N.; Bull. Nat. Inst., *loc. cit.*

Spine 4 to 8 inches in length, 6 to 10 lines wide; upper surface smooth, with a strong and sharp carination along the axis; wing of convex side widest; opposite wing narrow, and exhibiting a strong marginal sulcus, giving it a double edge; under surface of axis rounded, with several longitudinal sulci and carinæ, and with oblique angles at sides.

At the time of writing this description I have no sufficiently good specimen of this species to furnish a satisfactory figure. There are, however, better specimens in the collection of the late Dr. Mann, and I hope to have it well figured for another volume of the Report. I have little doubt that a spine of this species was the original of the figure published by Prof. Hall in the Geology of New York, Part IV., p. 174, although I have never seen the specimen, and in the figure the distinction between the central axis and the wings is not well preserved. A reduced copy of Prof. Hall's figure is given in Dana's Manual of Geology, p. 275. The only specimen of *M. sulcatus* which I have is considerably twisted.

Formation and Locality: Corniferous limestone; Milford, Ohio.

Genus LIOGNATHUS (n. gen.).

A small Placoderm, known as yet only by a jaw, found in the Corniferous limestone. This is spatulate in outline, dentated only at and near its anterior extremity. It has the general form of the dentary bone of *Dinichthys* and *Coccosteus*, and evidently belonged to a fish closely allied to them. It is even possible that it will hereafter be found associated with some small plates which occur in the Corniferous limestone, and which, from their resemblance to some of the plates of the carapace of *Coccosteus*, I have been inclined to refer to that genus.

Liognathus spatulatus (n. sp.).

Plate 29, Fig. 4.

Of this fish we have as yet only the right dentary bone. This is two inches long, by seven lines wide at its broadest part, somewhat triangular or spatulate in outline, its anterior extremity pointed, the posterior broadly rounded. The superior margin is nearly straight, and bears toward the anterior extremity a number of irregularly clustered, conical, blunt (?) teeth. At the extreme point is one (or more) longer, conical, acute tooth. The inner surface only of the jaw is exposed to view. This is flattened and smooth throughout. Probably the anterior portion of the exterior surface, if exposed, would be found to be roughened or tuberculated. As is mentioned in the generic description, the general form of this jaw is similar to that of *Coccosteus*, and it is a miniature copy of the dentary bone of *Dinichthys*. The resemblance is so strong that we must conclude that in this little jaw we have a relic of a hitherto unknown Placoderm which inhabited the Corniferous sea. I have, from the same quarries where this was found, a posterior dorsal plate which closely corresponds, in size and form, with that of *Coccosteus decipiens*, and it is not at all improbable that this plate once belonged to the same fish with the jaw under consideration. The figure given is of the natural size.

Formation and locality: Corniferous limestone; Delaware, Ohio.

Genus CYRTACANTHUS (n. gen.).

The above generic name is given to a remarkable fish-spine found by Mr. Hertzer at Delaware. It is broken at its superior extremity, and

somewhat exfoliated, but it shows enough of its original form and structure to make it certain that it is quite distinct generically from any fish-spine heretofore described. It is much curved, perhaps abnormally. The exterior surface was once generally tuberculated, except at the rough and expanded base. Its peculiar and diagnostic character is a single row of conical denticles set on the posterior side, limited to the *upper portion*, and *increasing in size from below upward*. Most defensive spines are much less curved, and have the denticles most strongly developed near the base of the exposed portion. They also increase regularly in size from above downward.

Since the specimen upon which this generic description is based is unique, little can be said in regard to its relations. In its curved form, expanded base, and denticulated summit, it recalls the peculiar cephalic spine of *Chimæra*, and hence suggests relationship with the large chimæroid teeth found in the same deposit. And yet the tuberculation of the surface is precisely that of some of the lateral spines of the cephalic buckler of *Aspidichthys armatus*, also found in the Corniferous limestone, and to be more fully described in another volume of this report.

Cyrtacanthus dentatus (n. sp.).

Plate 29, Fig. 5.

Spine 4 inches in length, cylindrical, $3\frac{1}{2}$ lines in diameter at center, larger above and below; base irregularly dilated, and hollowed out below; upper portion covered with small and closely set tubercles. Near the summit is a line of strong, conical, slightly depressed denticles, set on the middle posterior line. These denticles increase in size from below upward; the uppermost being more than a line in diameter and height. The figure given of this spine is of the size of nature.

Formation and locality: Corniferous limestone; Delaware, Ohio.

HOLOCEPHALI.

CHIMÆROIDI.

Genus RHYNCHODUS (n. gen.).

Teeth somewhat crescent-shaped or semi-circular, much compressed; the exterior margins regularly curved, the interior more nearly straight

and more or less thickened; one of the cornua produced and somewhat acute, the other more or less rounded and obtuse. The straight side of the tooth formed a triturating or cutting edge. In some species it was sharp and played upon the similar edge of the opposite tooth; in others it was broader and fitted for crushing mollusks or other food. Internal structure of teeth cancellated; the triturating surface being roughened by the extremities of calcigerous tubes. The number of teeth and details of dentition are not yet known, but we may infer from their shape that they were placed at the anterior extremities of the head to form a kind of rostrum or beak, much as the dental plates of *Chimæra* are placed. As none of the margins show marks of contact with other teeth, we may conclude there were but four having this form.

The internal structure of these teeth varies somewhat in the different species, adapting each to its functions. In *R. secans* the central portion is cancellated by interwoven calcigerous tubes, while the surfaces are composed of a tissue almost as dense as enamel, so that the cutting edges produced by the friction of opposing teeth on each other were kept constantly sharp and effective. In *R. frangens*, however—in which the upper edge is thick and presents a broad triturating surface to the opposite tooth—the dental tissue is cancellated throughout; affording by use that peculiar roughened surface so constantly seen on the teeth of the Cestracionts (*Psammodus*, etc.).

Among the large number of fish teeth from the Corniferous limestone which I have grouped in the genus *Rhynchodus*, there is considerable variety of form and structure; and yet, when nearly complete, they have so much in common that I have felt compelled to associate them together, and have supposed them to represent three species of a single genus. These species are described and figured in this report, and by reference to Plates 28 and 29 the characteristics of each form will be seen at a glance. In *R. secans* (Pl. 28, Fig. 1, 1*a*) the teeth have cutting edges. In *R. frangens* (Figs. 2, 2*a*, 3, of the same plate), with the same general structure and semicircular form, the edges are flattened and fitted only for crushing or triturating. In *R. crassus* (Pl. 29, Fig. 3) the upper surface is broader and more irregular, the whole tooth more massive and fitted for rougher work. The fundamental structure of all these varieties is, however, the same. They are all somewhat semi-lunar in outline, one of the angles being thickened, forming a kind of crown which was exposed to wear, while the rounded outline of the tooth is composed of comparatively thin walls, which apparently enclosed a process of the jaw on which the tooth was supported. This jaw was evidently cartilaginous, as all traces of it have generally disappeared. Not unfrequently nothing

but the crown of the tooth remains, the thinner walls below having been broken away. Such specimens are shown on Plate 28, Figs. 2*a*, 3. In the more complete specimens, such as are illustrated by Fig. 2, Plate 28, and Figs. 1, 2, Plate 29, although the entire outlines of the teeth are preserved, the thinner portions are crushed in and broken in such a way as to prove that these parts were filled and sustained by some core which has disappeared. The margins of all these teeth, when entire, are thin and rounded in outline, showing that they could not have been matched with others to form a complex dental series, but were solitary, or one set on each ramus of each jaw. Their microscopic structure is that of the teeth of Plagiostomous fishes, and is quite different from that of the teeth of any Ganoid known.

In one specimen which I have before me there are four of the teeth of *Rhynchodus secans* lying on a block of limestone, apparently holding nearly the position they did in life. They are surrounded by obscure traces of other portions of the fish that bore them, but nothing that has any distinct form or character.

In regard to the affinities of *Rhynchodus*, it seems to me that we have no good reason to doubt that they form the dentition of Chimæroid fishes, and that we have in them evidence of the existence on the globe of the *Holocephali* at a period long anterior to that in which their oldest remains have hitherto been found. As has been stated in the general review of our fossil fishes, the Chimæroids of our present seas (*Chimæra* and *Callorynchus*) are the remnants of an order of cartilaginous fishes which once held a much more important place than now in the fauna of the globe. In Europe the remains of the teeth of Chimæroids have been discovered in Tertiary, Cretaceous and Jurassic strata; but none in older formations, if we except the somewhat anomalous *Ptyctodus* found by Pander in the Devonian of Russia,* and of which a single tooth was discovered by Mr. Worthen in the Hamilton group, Calhoun County, Illinois, and described by him and the writer with the name of *Ptyctodus* (*Rinodus*) *calceolus*. (Geol. Surv. Ill., Vol. II., p. 106; Vol. IV., p. 374.) The affinities of *Ptyctodus* may be somewhat doubtful, although I have been inclined to consider the teeth described under this name as probably the dentition of some Chimæroid fish.

Whatever may be thought of the relations of *Ptyctodus*, those who are familiar with the fossil Chimæroids described by Sir Philip Egerton will probably not hesitate to group *Rhynchodus* with them.

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* See Pander's monograph "Ueber die Ctenodipterinen des Devonischen Systems," p. 48, Pl. 8.

Although the *Holocephali* have heretofore been supposed to be limited in their downward range by the Jurassic formation, since we have evidence that our living Chimæroids are only the remnants of an expiring fauna, it was to be expected that the life of this fauna would be found to reach far back in time; and it was quite consistent with all the facts before known to find traces of Chimæroids in Palæozoic rocks.

The Rays, on the other hand, are apparently a comparatively modern off-shoot from the original Selachian stock. We have no evidence of their existence at a period anterior to the Jurassic age, and they are evidently now in their epoch of fullest development; while the Chimæroids, in their decadence, should naturally have had an earlier birth.

Up to the present time no teeth of *Rhynchodus* have been discovered outside of the State of Ohio, nor in any other formation than the Corniferous limestone; but here they are not uncommon, though specimens as perfect as those now figured are extremely rare. For twenty years I have had in my possession fossils obtained at Sandusky and on the Islands, similar to that figured on Plate 28 (Fig. 2*a*), of which I could make nothing, until, by the discovery of more complete specimens, they were found to be only the solid anterior angles of teeth which were originally provided with large, semicircular bases. Fragments such as these doubtless exist in many collections, and, with the plates and descriptions now published, they will become intelligible to their possessors.

With the teeth of *Rhynchodus* we not very unfrequently find some peculiar fossils, of which one is represented on Plate 28 (Fig. 4.) They are oblong or imperfectly quadrangular in outline, of no great thickness, one surface flattened, the other concave. The flat surface is commonly marked with low, transverse ridges or lines of growth. The material composing them is dense and hard, more like dentine than bone. What these singular bodies are I am, as yet, quite unable to say; but from their microscopic structure I have been disposed to regard them as some portion of the dental apparatus of an Elasmobranch fish, and from their association with the teeth of *Rhynchodus* I have fancied they might have once belonged together.

Rhynchodus secans (n. sp.).

Plate 28, Figs. 1, 1*a*; Plate 29, Figs. 1 to 2*a*.

Teeth somewhat semicircular in form, posterior angle rounded or obtuse, the anterior prolonged into a more or less acute point; posterior and inferior margins thin and sharp, anterior and superior margins

thickened; surfaces smooth, almost polished; interior face flattened, exterior sloping from the anterior and upper thickened edges to the thin margins behind and below; upper margins nearly straight; anterior half often worn to a sharp, knife-like edge by contact with the corresponding edge of the opposite and overlapping tooth.

Of these singular teeth I have quite a number, from the upper portion of the Corniferous limestone at Sandusky and Delaware. In outline they form the segment—from one-third to one-half—of a circle, and are from three to four inches in length across the straight side. They were apparently four in number, so set as to form a kind of beak; those of opposite jaws playing on each other like the blades of shears. All the specimens I have are considerably worn, the anterior half of the upper margin being beveled off to form a straight, acute, cutting edge.

In general form and structure these teeth correspond closely with those I have described under the name of *Rhynchodus frangens*, but are smaller, narrower, smoother and much less thick and massive. They are also at once distinguishable by their cutting edges.

On Plate 28, Fig. 1, is represented a tooth of *Rhynchodus secans*, showing a much worn, cutting edge. Fig. 1*a* represents a section of the same. On Plate 21, Figs. 1 and 2, are represented a pair of these teeth placed in their supposed natural positions; while the outlines 1*a*, 1*b*, 1*c*, 2*c*, exhibit different forms of the anterior angle more or less modified by use. All these figures are of natural size. Figs. 1 and 2, Pl. 29, are taken from a group of four found together and forming apparently the dentition of a single fish.

Formation and Locality: Corniferous limestone; Sandusky and Delaware, Ohio.

Rhynchodus frangens (n. sp.).

Plate 28, Figs. 2, 2*a*, 3.

Teeth semi-lunar in form, one side slightly concave, the opposite margin strongly convex and regularly rounded; type specimen four inches and eight lines in length, depth at the crown of the arch, two inches and nine lines; sides flattened; greatest thickness, six lines; concave side showing a triturating surface on its anterior half and rising upward into a beak-like point; lateral surfaces smooth and polished; the lower and rounded portion of the tooth formed by thin walls of bone inclosing a deep pulp-cavity?; crown portion thick and strong.

The above description is based upon a tooth which seems to exhibit

an unusual perfection of preservation, inasmuch as there are several in the collection before me which apparently represent the crown portion—the massive anterior angle with its beak-like point and triturating surface—while the broad and smooth expansion of the side formed by the thin and shelly portion is altogether wanting. It is, however, possible that these are corresponding teeth from opposite jaws of which one form exhibits a crown portion with a broad expansion of marginal wall inclosing, perhaps, a pulp-cavity, while the other is simply concave below for adaptation to the convex surface of a supporting jaw; just such a difference, indeed, as is seen in the teeth of the upper and lower jaws of *Callorhynchus*.

The microscopic structure of these teeth is similar to that of many of the teeth of extinct Selachians, such as *Cochliodus*, *Psammodus*, etc., viz., a cancellated or reticulated tissue formed by radiating and branching calcigerous tubes completely solidified near the exterior, but wearing in such a manner as to leave a peculiar roughened and punctate grinding surface. The general form of the most perfect of them is very similar to that of those I have designated by the name of *Rhynchodus secans;* but in that species the lower margin is not so strongly arched, and the crown forms a cutting edge which played on that of the opposing tooth. If my view that these are the teeth of Chimæroid fishes is accepted, it will perhaps be thought that the differences between these two species have generic value, as they are quite as striking as those which separate the genera *Edaphodon*, *Ganodus*, *Ischiodus*, *Elasmodus*, etc. Yet, as it seems to me, with so little material before us, and knowing so little of the complete dentition of either species, it would be somewhat premature to attempt now to define more than one genus.

The resemblance presented by these teeth to those described by Buckland under the name of *Chimæra Townsendii* (Proc. Geol. Soc., Lon., II., p. 206) is so striking, that to any one who will make the comparison the question will seem to be not so much whether the teeth under consideration are those of a Chimæroid fish, as whether the present species and that of Buckland do not belong to the same genus.

Rhynchodus crassus (n. sp.).

Plate 29, Fig. 3.

Teeth large and strong, 3 to 5 inches in length, $1\frac{1}{2}$ to 2 inches in breadth. Base expanded with a somewhat semicircular outline, from which the sides converge upward to an irregularly flattened and rough-

ened crown, which rises at the anterior extremity into a pointed prominence. Base excavated. Crown thick and strong, upper surface showing attrition from use.

In the tooth described above, we have a form of which a number of examples have been taken from the Corniferous limestone, none of which, however, are sufficiently complete to enable us to give all desirable details of their normal outlines and structure. So far as we can judge from this material, the original form of these teeth was not unlike that of the one I have described under the name of *Rhynchodus secans*, but they were evidently much broader and stronger, and fitted rather for crushing than cutting. For the reasons already given, I have been led to group these with the other teeth now described under the same generic title, and to regard them as the remains of fishes having more affinity with *Chimæra* and *Callorhynchus* than with any others now living. Probably the accumulation of more material will enable future palæontologists to determine more accurately the relations of this group of fishes with each other and with our living fauna; and it is possible their researches will modify in some degree the views now advanced. I have thought, however, that the publication of figures and descriptions of this singular group of fossils would at least serve a useful purpose in stimulating collections and researches by which their structure and relations would be more fully ascertained.

Formation and locality: Corniferous limestone; Sandusky, Delaware and Kelley's Island.

PLACODERMI.

Genus DINICHTHYS (n. gen.).

This was a very large Placoderm allied to *Asterolepis*, *Coccosteus*, etc., but apparently far exceeding them in dimensions. The cranium was composed of thick, bony plates, strengthened with massive internal arches, all firmly anchylosed together, forming a bony box, not yet found disarticulated, which was at least two feet in length and breadth. Within the osseous cranium there was doubtless a cartilaginous brain-case, but the solid bone of the occipital portion was three inches in thickness.

The dentary apparatus consisted, First, of relatively small and thin, somewhat triangular maxillaries, which bear on their margins a number of conical, acute, anchylosed teeth, formed by the prolongation of the bony tissue of the jaw. These teeth interlocked with a similar series on the mandibles. Second, in advance of the maxillaries, the premaxillaries

are developed into large and strong triangular dental plates or teeth. Third, the mandibles consist of a dental bone, in some species, two feet or more in length, flattened and spatulate behind, turning up anteriorly to form a strong triangular tooth, which, with its fellow of the opposite mandible, interlocked with the great divergent premaxillary teeth. Midway of the dentary bone, in some species, the upper margin was prolonged into a series of conical teeth which matched with those of the maxillaries, and between this series of relatively small teeth and the upturned extremity of the mandible, a single large triangular tooth was formed by the prolonged jaw tissue. The articular extremity of the mandible, which was probably cartilaginous, and was spliced on to the dentary bone, has not yet been discovered. The union between the mandibles at the symphysis was apparently very slight, as the approximated surfaces are smooth, and the jaws are always found disconnected. The tissue of those portions of the mandibles, maxillaries and premaxillaries which served the purposes of teeth, is exceedingly dense, resembling enamel in this respect. The surfaces are also smooth and highly polished. Along the inner face of the triangular tooth formed by the upturned end of the mandible, in some species, a single line of pitted tubercles form an evident and even striking ornamentation. A similar row of tubercles is seen on the outer surface of some of the great premaxillary teeth, as shown in Plate 31, Figs. 1 and 2.

The external surface of the cranial bones and mandibles shows a peculiar, fine, vermicular or reticulated marking, quite different from that of the surface bones in the allied genera. The cranial surface is also seen to be marked with a series of narrow, simple furrows, which form an ichthyic arabesque that has no relation to the sutures which unite the cranial plates.

The body of *Dinichthys* would seem to have been protected by plates which formed a carapace, as in *Coccosteus*, *Pterichthys* and *Asterolepis*. Not all the plates composing this armor have yet been found, but we have enough of them to know that it enclosed the body less completely than in *Pterichthys* and *Coccosteus*, but more so than in *Asterolepis* and *Heterostius*. The plates which protected the under side of the body were large, but relatively thin, and were perhaps partly covered with integument, as they show little of the peculiar vermicular ornamentation of the upper surface. The plates of the back were very large and thick, and must have covered all the vital parts of the body. Of these, the dorsomedian shield, which occupied the middle portion of the back, was sometimes fully two feet in length and breadth. In outline it approaches the same bone in *Asterolepis*, but is fully twice as large. It bears on its

under surface a strong median crest which in its highest portion projects more than four inches from the concave arch of the plate. It is also prolonged into a neck-like extremity, which extends several inches beyond the outline of the dorsal shield. The form of this remarkable bone will be best understood by reference to the figures on Plate 32, of which the largest is one-fourth, the others one-eighth natural size, linear.

On either side of the dorso-median shield was located a large and flat Supra-scapular (*os articulare corporis* of Pander). These bones had in *Dinichthys* much the same form and position as in *Coccosteus*, though very much larger, as will be seen by a comparison of the figures now published (Plate 34, Figs. 1 and 2) with those given by Pander (*Ueber die Placodermen des Devonischen Systems*, Taf. 3, Figs. 10*a* and 10*b*, Taf. 7, Figs. 2*b* and 2*b'*). As in *Coccosteus*, this bone has a strong and prominent condyle which moved in a socket in the plate which formed the posterior lateral angle of the cranium (*os articulare capitis* of Pander), Plate 34, Figs. 3, 3*a*, 3*b* and 4.

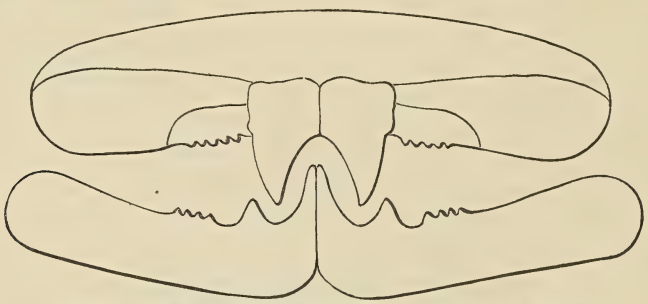
No scales have yet been found with the remains of *Dinichthys;* and from their absence we may infer that, as in *Coccosteus*, the posterior portion of the body was covered simply with a tough skin. We are unable to say, from any evidence yet before us, what the form of the body was; whether it was short and massive, as in *Pterichthys* and *Coccosteus*, or more elongated, as in *Asterolepis* and *Heterostius*. We may infer, however, from its affinities, which are closer with *Coccosteus* than with *Asterolepis*, that the body was relatively short and massive. We know that it could not have been less than $2\frac{1}{2}$ to 3 feet in diameter, but it is impossible to say whether the fish was 10 or 15 feet in length, and we do not yet know what was the number and form of the fins.

Though presenting some striking peculiarities, the structure of *Dinichthys* exhibits so many points of resemblance to that of the group of Placoderms already described — *Asterolepis*, *Coccosteus*, etc.—that there can be no doubt that it was a member of this order, and apparently the most gigantic of all. The dental apparatus of *Dinichthys* is its most remarkable feature, and at first sight it would seem entirely without parallel among living or fossil fishes. The huge triangular teeth formed by the modified premaxillaries are certainly very different from the teeth borne by any other member of the Placoderm group, and yet they are not very unlike the dental plates of the *Chimæroids*, and are less heteroclite than the dentition of some modern fishes, as, for instance, that of *Scarus*.

Among the old Devonian fishes the dentition was scarcely less varied than in those of the present day; and in those which have been obtained from the Devonian rocks of Ohio, and are described in this report, there

are some of the most extraordinary modifications of dentition known. For example, *Macropetalichthys* was probably, like the Sturgeon, edentulous. *Onychodus* carried a crest of relatively large teeth upon an arch of bone set between the extremities of the mandibles. These teeth seem not to have matched with any in the upper jaw. The teeth of *Rhynchodus* form a parrot-like beak, as do those of *Chimæra*, one species having teeth with sharp edges which played upon each other like the blades of shears. In another the heavy semicircular teeth, four to five inches in diameter, were fitted for crushing rather than cutting. In *Dinichthys* the massive jaws are themselves transformed into teeth more singular in their structure, and more formidable than those of any living fish. Although so peculiar, the dentition of *Dinichthys* is not so different from that of *Coccosteus* and *Pterichthys* as might at first sight appear. In all these we have the same consolidated, spatulate mandible, with a series of anchylosed teeth occupying the middle of its upper margin. These teeth are formed by the condensation and prolongation of the tissue of the jaw, while in many fishes the teeth are implanted in sockets, or have a ligamentous attachment to a cartilaginous support.

In the accompanying diagram I have attempted to give a plan of the dentition of *Dinichthys*.



DENTITION OF DINICHTHYS, ONE-TWELFTH NATURAL SIZE, LINEAR.

It will be understood that in this figure the jaws are represented as spread so as to be fully seen from the front. In life the posterior ends of the mandibles were brought so near together that their form could not be distinctly seen in a front view. To obtain a just idea of the formidable nature of this dentition, it should be remembered that each of the mandibles is *two feet* in length.

Dinichthys Hertzeri (n. sp.).

Plates 30 to 34.

As the remains of this great fish have served as a basis for the generic description of *Dinichthys*, they have already been so fully described that

little more is required to give a clear idea of its size and structure. The bones of *Dinichthys* collected at Delaware, Monroeville and Sheffield, have been provisionally referred to *D. Hertzeri*, but it is by no means certain that all should be referred to one species, as they show differences in structure which indicate sexual or other varieties, or distinct species. These points of difference will best appear in the detailed descriptions of the different bones.

Cranium. The form of the posterior portion of the cranium is well shown in the two figures given on Plate 33. Of these, one represents the outside, the other gives an inside view of a specimen obtained from the Huron shale, in Sheffield, Lorain County, by Mr. J. Terrell. Another cranium, found by Mr. A. W. Wheat at the same locality, presents essentially the same features, though on a larger scale, inasmuch as the diameter of the posterior portion of the larger cranium is 24 inches, of the smaller, 16 inches. It will be seen, by reference to the figures, that the various plates which compose the skull in *Dinichthys* are firmly soldered together, so that their outlines cannot be fully and accurately determined. The posterior margin of the cranium is formed by the representatives of the Supra-occipital, the Squamosal and Epiotic plates. These coalesce to form a massive arch which presents in some portions a thickness of over three inches of solid bone. The posterior margin of the Supra-occipital, which forms the summit of the crescent of the posterior outline of the skull, shows almost precisely the form and structure of the corresponding bone in *Heterostius*, viz., in the crown of the arch is seen a pyramidal tubercle projecting posteriorly, while immediately anterior to this, and not well shown in the figure, is a deep pit, which is sometimes single in *Dinichthys*, but oftener is composed of two depressions, as in *Heterostius*, *Asterolepis* and *Coccosteus*. The posterior lateral angles of the head are formed by the articular margin of the Epiotic (*os articulare capitis*), better shown on Plate 34, Figs, 3, 3*a*, 3*b* and 4, than in the general view, Plate 33. The projecting point shown in all these figures is a rest or guard which strengthened the articulation. The joint itself is formed by a deep cylindrical socket, into which fits the condyle of the Supra-scapular in such a way as to form one of the strongest and most complete articulations in the whole animal kingdom. In the specimen figured on Plate 33, only the posterior and central portions of the cranium are shown. The bones of the anterior and lateral portions seem to have been united by cartilaginous attachments, so that they are generally disconnected. Two very massive, somewhat triangular bones were found by Mr. Wheat occupying the position of the bones numbered F. in Hugh Miller's diagram, and called by him Posterior-frontals. Of

these, the under sides are roughened and deeply pitted, apparently to afford firm bases for the great premaxillary teeth.

In one specimen discovered by Mr. Hertzer the entire cranium was present, and not very much distorted. This afforded very precious information regarding the aspects and structure of the anterior portion of the head. Unfortunately, the upper surface was so firmly attached to the rock that the plates were considerably exfoliated in its removal. The maxillaries are, however, seen in position, and the premaxillary teeth holding their proper place, with the exception that one is somewhat twisted laterally. Under the cranium, in this specimen, the mandibles were found lying together, and though detached, their ends were pointing up between the premaxillaries. The position of the bones in this head has revealed to us all the generalities of the structure of the jaws and teeth in *Dinichthys*, and forms the basis of the restoration given in the diagram on a preceding page.

Mandibles. The form and structure of the mandibles have been given in a general way in the generic description. To that I would add, however, that the polished and ornamented interior faces of the triangular tooth formed by the upturned end of the mandible seem to me to render it at least probable that, instead of uniting to form *one* tooth, the pointed extremities of the mandibles were slightly divergent, so as to form *two* teeth; both of which, however, passed between the extremities of the premaxillaries in the closure of the mouth. Among the mandibles found at Delaware, I have noticed an interesting difference of form. In some—like that figured on Plate 30—a conspicuous triangular point or tooth is raised between the anterior extremity and the series of small teeth set near the middle of the dentary bone. In other specimens this seems to be entirely wanting; a variation which may, however, be only dependent on age or sex. The smaller teeth, to which I have referred, are represented, natural size, on Plate 31 (Fig. 3.)

Premaxillary teeth. From the center of a concretion found at Delaware was taken the absolutely perfect tooth figured, natural size, on Plate 31. It will be seen that the outline of this tooth is triangular, that it occupied the anterior lateral angle of the muzzle and arched around from the front to the side. Above, it is broadly expanded, flattened, and more or less rough, for co-adaptation with the associated bones. Below, it is composed of dense and polished tissue, which indicates great hardness and strength in this portion of the tooth. From its size, form, and jet-black color, as it lay partially exposed in the rock, it suggested the half of the hoof of the elk or moose. This tooth has evidently seen much service, for the shoulder which it presents on Plate 31, Fig. 1, is evidently, for the most

part, made by contact with the tubercle or subordinate tooth of the mandible. A tooth found by Prof. Allen, on the Lake shore at Sheffield, and which evidently corresponds to that now figured, shows a remarkable deviation from it in form. With equal or greater length, it is scarcely more than half as wide; and, instead of terminating above in a squamosal margin, shows here a massive ovoid tuberosity, such as has evidently been impacted in some cavity of the cranial bones. This tooth is also without the ornamentation formed by the line of tubercles shown in the figure. These differences are so marked that it would not be surprising if it proved that we had here the remains of two distinct species. Additional material, illustrative of the structure of *Dinichthys*, will doubtless be obtained before the completion of the Geological Survey, and when another volume shall be published we may have the means of definitely settling this question.

Dorsal Shields. Of the plate-armor which enclosed the central portion of the body of *Dinichthys*, the most interesting portions are figured on Plates 32 and 34, and have been already described. The dorso-median shield is sufficiently well shown in the figures now published, to enable any one to form a clear idea of its structure. They will very likely, however, fail to get from the reduced figures an adequate appreciation of its magnitude, and realize that it is more than two feet in diameter in both directions. Those who have access to the monograph of Prof. Pander on the Placoderm fishes of Russia, will see that the dorsal shield of *Dinichthys* presents considerable resemblance to those of both *Asterolepis* and *Heterostius*, and yet is sufficiently distinct from both. In general outline it more closely resembles the dorsal plate of *Asterolepis*, while in the neck-like projection of the inferior crest, it is much more like that of *Heterostius*. In its fine, inconspicuous ornamentation, its outer surface differs widely from the tuberculated exterior of the bones of all its congeners, *Heterostius*, *Asterolepis*, *Coccosteus*, etc.

Supra-scapular. The Supra-scapular of *Dinichthys* (*os articulare corporis* of Pander) is represented in our collections by a number of more or less complete specimens. From these we learn that it was somewhat oblong or rudely triangular in outline, terminating on either margin with broad, squamosal surfaces, where it was overlapped by other plates. Its anterior margin bears a remarkably formed articular condyle, which is a wonder of adaptation. It was so inserted into the socket of the *os articulare capitis* as to form a strong and perfect joint—one which gave considerable motion to the parts joined, and yet that locked them together so firmly that they could not be separated without the fracture of either the condyle or socket, both of which were very strong.

Our first knowledge of *Dinichthys Hertzeri* we owe to the industry and acuteness of observation of Rev. H. Hertzer, a clergyman stationed for two years at Delaware, Ohio; and who, while performing his ministerial duties, and receiving a very small salary, still found time to make many important collections and observations in geology. The town of Delaware is located upon the line of junction of the Huron shale and the Hamilton and Corniferous limestones. The Corniferous abounds in fossils, and Mr. Hertzer collected a splendid suite of the ichthyolites which characterize this formation; but the Huron shale had, up to this time, been regarded by all geologists as barren ground—nothing but a few *Lingulæ* and *Discinæ* having been obtained from it. Near its base the Black shale contains, both at Delaware and elsewhere, a great number of concretions composed of impure limestone. These are often quite spherical, and ten feet or more in diameter. In examining some of these septaria which had been split, apparently by the frost, Mr. Hertzer discovered that they not unfrequently contained masses of silicified wood (*Dodoxylon Newberryi*, Dawson,) or fragments of bones that had served as nuclei around which they had formed. Of these bones several were taken by Mr. Hertzer to the meeting of the American Association at Buffalo, in 1866. There they were submitted to me, and I recognized them as the bones of huge Ganoid fishes, altogether new to science. With enthusiasm fired anew by the interest these specimens excited, Mr. Hertzer devoted all the time possible to further examinations of the concretions which contained them. The results of his efforts were communicated to me from time to time, in letters, in which each of the discoveries that resulted in the almost complete restoration of the head of *Dinichthys* is graphically described. The rock which contains these fossils is one of the toughest and most intractable known, and Mr. Hertzer deserves great credit for the care and skill with which hundreds of fragments were carefully gathered, and each cemented in its proper place. In one of these concretions Mr. Hertzer found a head of *Dinichthys*, of which the component parts, though somewhat dislocated, were all present. In another was a complete mandible, and in still another, one of the great teeth of the upper jaw. Though much broken, both of these latter specimens were restored by Mr. Hertzer nearly to their former integrity, and they now constitute the pride of the collection of the School of Mines of Columbia College.

The specimens which occur in the cliffs on the Lake shore at Sheffield, Lorain County, are not found in concretions, but simply imbedded in the shale. Generally a thin coating of "cone-in-cone" covers all their surfaces; and doubtless if there had been more lime in the carbonaceous

mud which now forms the Huron shale, the bones would have been more completely enveloped with calcareous material. From the circumstances in which they occur, the bones found at Sheffield are much more easily detached from their matrix than those which are included in the concretions at Delaware and Monroeville; hence we must look to the former locality for the most numerous and satisfactory specimens of this gigantic fish. At Sheffield the cliff is constantly worn away by the waves, and the fragments of bone may from time to time be noticed projecting from the weathered face. These fragments attracted the attention of Mr. Terrell some years since, and we now owe to his intelligent interest in them some of the most complete and instructive specimens known.*

In consequence of the compression suffered by the shale from the weight of the overlying rock, the Sheffield specimens are found very much crushed and broken. Great care is therefore necessary in getting them out, freeing the fragments from their calcareous crust, and reuniting them each in its proper place. Much patience and skill has been expended by Mr. Wheat in the restoration of the specimens obtained by him at Sheffield. All the more important ones have passed through his hands, and they owe much of their completeness and symmetry to his care and skill. It is a somewhat remarkable fact that among some hundreds of fragments of the bones of *Dinichthys* obtained at Sheffield, only a single premaxillary tooth has yet been discovered, and no portion of the maxillaries or mandibles. We are therefore wanting in materials for comparing satisfactorily these specimens with those obtained at Delaware. The difference in form of the great tooth obtained by Prof. Allen at Sheffield, from those collected at Delaware by Mr. Hertzer, has been remarked upon, and it will not be surprising if two

*I regret to be compelled to report that, since the above paragraph was written, the finest specimens discovered by Mr. Terrell, and those represented on Plates 32 and 33, have been destroyed by the fire which consumed Ely's block, in Elyria. It is to be hoped that this sad misfortune will prompt those who may hereafter secure fine and unique specimens illustrating our palæontology, to place them at once in some repository where they will be safe from the all-devouring element; for it seems that fate has decreed that, without such a precaution, their destruction is simply a question of time.

Another suggestion is scarcely of less practical importance, and that is, that all remarkably fine specimens should be carefully photographed as soon as convenient after their discovery. We may congratulate ourselves that Mr. Terrell's thoughtfulness in this respect has saved his specimens from being utterly lost to science; for the photographs which he had taken have supplied the material for the plates to which I have referred, and have thus made the more important features of his specimens immortal.

or more species of *Dinichthys* should be found to be represented in the two localities. This probability is somewhat strengthened by the fact that the bones obtained at Sheffield are from the extreme upper layers of the Huron shale, while the Delaware specimens are from the base of the formation.*

Sections of the bones and teeth of *Dinichthys* have been made by Mr. John E. Gavitt, of New York. These, when examined under the microscope, reveal some interesting and instructive phases of bone tissue. It has not been possible, however, to have figures made from these sections in time for introduction into this volume, but it is hoped that they will be illustrated in the future publications of the Geological Survey.

Genus ASPIDICHTHYS (n. gen.).

A Placoderm fish of large size, having a carapace composed of massive, bony plates, of which the middle plate of the back—"dorso-median"—is similar in form to that of *Pterichthys*, but many times larger, and is covered with large, hemispherical, smooth, enameled tubercles.

Up to the present time one entire dorso-median plate and a few fragments of others are all that we have obtained of this remarkable fish. When other portions of his plate armor shall be found, they will probably be seen to correspond most nearly with that of *Pterichthys*. The tuberculation of the surface is, however, very different from that of *Pterichthys*, and, as the dermal ornamentation is very characteristic in these old fishes, it is undoubtedly indicative of differences which have generic value.

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* Since the above description was written, a mandible of *Dinichthys* has been obtained from the summit of the Huron shale, at Sheffield, Lorain County, by Prof. A. A. Wright, which gives us some new light on the dentition of this remarkable fish. This mandible is smaller than those from Delaware, being only eighteen inches long, and shows several points of difference in form; but its most striking feature is a sharp cutting edge along the anterior third of its length—an edge formed by the friction upon it of the maxillary and premaxillary which shut over it, their edges playing upon its edge precisely as scissor blades play on each other. In this specimen the denticles seen on the upper margin of the mandible now figured (Plate 30) are obsolete, the margin of the jaw being raised into a thin edge, evidently for cutting only.

These specimens will be fully described and figured in another volume of our Report. They will doubtless form a second species of the genus, for which I propose the name of *Dinichthys Terrelli*, to commemorate the zeal and intelligence shown by Mr. Jay Terrell in the collection of this interesting fossil at Sheffield, Lorain County Ohio.

By Pander, *Pterichthys*—of Agassiz and Hugh Miller—is called *Asterolepis*, as he identifies it with *Asterolepis* of Eichwald. But Eichwald's description and name were based on a fragment so uncharacteristic that it is quite impossible to be certain what it is; while the names *Asterolepis* and *Pterichthys* have been so thoroughly identified with the fishes to which Agassiz and Hugh Miller assigned them, that it would produce great confusion to attempt to change them. Pander called *Asterolepis* of Agassiz *Homostius*, but his example has not been followed by others.

Aspidichthys clavatus (n. sp.).

Plate 35, Figs. 1 and 2.

Of this huge and remarkable fish very little is known, as only some portions of the dorsal plates have yet been found. These are, however, so peculiar and so different from anything else known to palæontologists that they will serve to identify unmistakably one of the largest and most singular of the great Placoderm fishes that inhabited the Devonian seas.

The most significant fragment of *Aspidichthys* yet discovered is a nearly entire median dorsal plate, obtained by Mr. Hertzer from the Huron shale at Delaware, Ohio. This plate is an elongated hexagon, or short, coffin-shaped, having, indeed, almost exactly the form of the dorso-median plate of *Pterichthys*, but a hundred times as large; for, while the largest plate of *Pterichthys* is 12 by 18 lines in dimension, the corresponding plate of *Aspidichthys* is as many inches in each direction, or, more exactly, is 13 by 17 inches, and a portion of it is wanting. It is more than an inch in thickness in the central portion, and is keeled below as is the same plate in *Dinichthys* and *Asterolepis*. The most striking feature in this plate is, however, its external ornamentation. This consists of knobs or bosses of smooth, shining enamel, of the size and form of split peas.

In its general aspect this tuberculation resembles that of *Pterichthys* and *Coccosteus*, but differs strikingly in this, that the tubercles are perfectly smooth and polished, and show nothing of the stellate ornamentation which is to be seen on the plates of nearly all the great mailed fishes of the Old World. This character has, doubtless, generic value, but the form of the dorso-median plate is so nearly that of the same plate in *Pterichthys Milleri*, that, if it were not for this peculiar tuberculation, we might conclude that we had in this fish nothing more than a huge monster of a *Pterichthys*.

The margins of the plate under consideration are beveled off and

straightened in such a way as to prove that it articulated with others, and there is no reason to doubt that it formed part of a carapace similar to that of *Pterichthys*.

Plate 35, Fig. 1, represents the dorso-median plate of *Aspidichthys*, very much reduced; Fig. 2, a portion of the same, natural size.

Formation and Locality: Huron Shale; Delaware, Ohio.

DESCRIPTIONS OF

FISHES OF THE CARBONIFEROUS SYSTEM.

ELASMOBRANCHII.

SQUALI.

Genus CTENACANTHUS, Agass.

Fin-spines of moderate or large size, compressed, gradually tapering, moderately arched backwards; anterior face narrow, rounded; posterior face concave, with a moderate cavity, the lateral edges bordered by two rows of curved denticles, inclining downwards; exposed surface marked with strong, longitudinal ridges and furrows, pectinated by transverse ridges, scales or tubercles; base of moderate size, rapidly tapering, finely striated or roughened.

Defensive spines belonging to this genus are, perhaps, more widely distributed than any others known. Numerous species have been found in the Old World and the New. Most of these have been obtained from the Carboniferous rocks, and it is evident that the fullest development of the family of sharks which bore these spines took place in the Carboniferous age. But several species are now known which were obtained from Devonian strata, and of these, by far the finest, *Ct. vetustus*, is figured and described in this volume. Barrande carries the date of the beginning of *Ctenacanthus* much farther back, as he describes a species (*Ct. Bohemicus*) which occurs in the Upper Silurian and Lower Devonian strata. There is, however, some question whether this species should be included in the genus *Ctenacanthus*. It is not yet certainly known what teeth were associated with the spines of *Ctenacanthus*, but there is little doubt that they have been described under different names. From the association of teeth of *Orodus* and spines of *Ctenacanthus* in the Waverly Shale at Vanceburg, Ky., I have been led to suppose that they were originally parts of the same fish. We may confidently expect, however, that in the formation and locality where the specimens to which I allude were

obtained, we shall before long procure material that will enable us to settle this question, just as a similar question has been set at rest in regard to the relationship of the teeth and spines of *Hybodus* and *Acrodus* in the Jurassic.

Another inquiry is suggested by the results of the study of the Jurassic sharks, and that is, whether there were one or two spines on the back of *Ctenacanthus*. It has been proved that in *Hybodus* there were two, differing somewhat in form and markings. These questions will be referred to again in the descriptions, to be published in another volume, of *Orodus variabilis* and *Ctenacanthus furcicarinatus* found at Vanceburg, Ky.

Ctenacanthus is exclusively Palæozoic in its range, and the sharks which bore these spines must have been sometimes of formidable dimensions. Some specimens of *Ct. major*, from the Coal Measures of England, are considerably more than a foot in length, and very strong. A specimen of *Ct. formosus*, Newb., found in the Waverly, at Warren, Ohio, is fourteen inches in length. This will be figured in another volume of this Report.

Ctenacanthus vetustus (n. sp.).

Plate 35, Figs. 3, 3*a*, 3*b*, 3*c*, 3*d*.

Spine of medium size—6 to 8 inches long—robust, gently arched backward, rapidly tapering to the point; buried portion conical, nearly smooth; exposed portion ornamented with 16 or more nearly equal ridges—those on the sides for the most part simple, but sometimes forked at base and nearly smooth; those on the anterior margin pectinated so strongly as to afford a marked specific character; section conical; posterior surface flattened, with a strong, rounded, longitudinal mesial ridge; medullary cavity small, opening backward at the base of the ornamented portion.

This beautiful spine is the first well marked species of *Ctenacanthus* found in the Devonian rocks of Ohio. Its most striking peculiarity is the smoothness of the lateral carinæ and the strong pectination of the anterior margin.

Formation and locality: The specimen on which this description is based, was obtained from the Huron shale at Avon Point, Lorain County, by Mr. J. W. Hulbert, of Elyria, to whom I owe the opportunity of describing it.

Ctenacanthus Marshi (n. sp.).

Plate 36, Figs. 3, 3*a*, 3*b*.

Spine short and robust, much compressed, broad at base, rapidly tapering to a sub-acute point; anterior margin straight or gently arched;

posterior border very oblique; buried base broader than superior portion, rounded below, laterally flattened, finely striated; pulp cavity very broad, opening posteriorly below the ornamented portion; line of demarcation between plain and ornamented surfaces curved; exposed portion of spine much flattened below, more rounded above; anterior margin acute; posterior face concave, forming a broad longitudinal groove, on the margins of which are set a few tubercular denticles; lateral surfaces marked with relatively few, strong, nearly plain, enameled ridges, those near anterior border strongest and most continuous, nearly straight, and parallel with the margin; toward the posterior edge they are shorter, more numerous and oblique; the summits of these ridges in places faintly beaded, but no where pectinated; width of spine at base, 18 lines; length, 7 inches; thickness, 7 lines.

Two specimens of this spine are before me, one of which I owe to the kindness of Col. J. W. Foster, of Chicago, the other to Prof. O. C. Marsh, of Yale College. Both want the superior extremity, but show the middle and basal portions nearly equally well. They indicate a short, robust, compressed and strongly carinated species, very unlike any other yet found in America.

In the general character of the surface markings, these spines closely resemble those figured and described by Agassiz under the name of *Ctenacanthus major;* and they agree also with Agassiz's description so far as regards the ornamentation, but not in regard to form or the "acute posterior margin"—the latter being a most anomalous feature in the spines of *Ctenacanthus*, all of which, so far as I know, have a flattened posterior surface. The spines under consideration are much shorter and relatively thicker than those of *Ctenacanthus major*, and are also distinguished from those described by Prof. Agassiz, by the obliquity of the short ridges which cover the posterior half of the sides near the base.

It is possible, however, that both the specimens which have come into my hands are from the posterior dorsal fins, where the spines (if there were two in *Ctenacanthus*) would almost necessarily be shorter than those of the first dorsal. This is strikingly true of the spines of *Hybodus* and *Acrodus*, as shown by Mr. Day in his paper published in the first volume of the Geological Magazine; and if I am correct in the suggestion I have made, that the spines forming the genus *Ctenacanthus* belonged with the teeth known as *Orodus*, there was a close relation between these genera, *Orodus* and *Ctenacanthus* forming the Carboniferous representatives of the Jurassic *Acrodus*.

I have some large and massive spines from the Coal Measures of Scotland, which, with nearly identical surface markings, are twice as long

as these, and they have the posterior margins, not acute, as Prof. Agassiz represents his specimens of *Ctenacanthus major*, but broadly concave, as in the specimens before us. These spines come to me as those of *Ctenacanthus major*, and suggest the probability that Prof. Agassiz was misled by the imperfect exposure of the specimen he figures, and that if this were properly developed it would show a flattened, striated posterior surface, as do the other species of the genus.

If Prof. Agassiz is correct in representing the section of *Ctenacanthus major* as lenticular, and both margins acute, our specimens must be considered distinct. If, however, his description is erroneous, and the spines of *Ctenacanthus major* are posteriorly flattened, we have no well marked characters with which to distinguish our specimens from the European, except the smaller size and more robust figure of ours. It is possible, as has been remarked, that this striking difference may depend on the different positions of the spines, and that all the European specimens of which I have any knowledge are anterior, and that both our specimens are posterior dorsals; but this is hardly probable. Until such time, therefore, as we shall have obtained more material bearing on the question, we shall be compelled to consider our Zanesville spines as representing a new species. To this species I have given the name of Prof. O. C. Marsh, of Yale College, who has kindly loaned to me for examination the best specimen yet found.

Among the *Ctenacanthus* spines described abroad, there are none so short and thick as these, unless it be those of *Ctenacanthus tenuistriatus*, Ag., in which the carinations are much finer and more numerous.

Formation and locality: Coal Measures, near Zanesville, Ohio.

Ctenacanthus formosus (n. sp.).

Plate 36, Figs. 2, 2*a*, 2*b*.

Spine very long (14 inches), slender, curved, broadest at base (1 inch), narrowing to a long acute point; much compressed laterally; basal portion relatively short, rounded below, flattened laterally, surface covered with a fine, longitudinal striation; exposed portion marked with numerous, sharp, continuous, pectinated carinæ (about 25 at base, 15 in the middle), those occupying the middle portion of each side being finest; posterior face flattened and slightly concave, the angle on either side set with small, crowded, hooked denticles; pulp cavity relatively small, opening to posterior surface at the junction of the ornamentation with the base.

The size of this spine, its graceful curve, and elegant ornamentation, combine to render it the most beautiful of all the species known to me of the genus. The basal portion is unusually short, broad and compressed. The angle formed by the line of junction of the ornamented and plain surfaces with the axis of the spine is of about 45°. The enameled ridges on the sides are more numerous, sharper, and more continuous than in any other known species. These characters, with its compressed section and curvature, will serve to identify it at a glance.

Formation and locality: This species of *Ctenacanthus* is a characteristic fossil of the Waverly. I have fine specimens obtained from the Cuyahoga Shale by M. C. Read, at Warren, Trumbull County; from the Berea Grit, at Chagrin Falls, by C. T. Blakesley, Esq.; and from the "Waverly Black Shale," at Vanceburg, Kentucky, by Capt. Patterson.

Ctenacanthus triangularis (n. sp.).

Plate 36, Figs. 1, 1*a*, 1*b*.

Spine of medium or small size, 4 to 6 inches in length, straight or slightly curved, robust; section triangular; pulp cavity large, opening to posterior surface above the base; basal portion broadest, oblong in outline, irregularly rounded at the extremity, marked with a fine, longitudinal, vermicular striation; exterior portion broadest below, tapering regularly to the triangular point; lateral faces marked at the base with about twelve longitudinal, pectinated carinæ, which are largest near the anterior margin, and diminish in number and strength toward the nearly smooth summit; posterior face flattened or slightly concave, with an obscure ridge along the median line, the whole covered with fine vermicular, longitudinal markings; the posterior angles of the upper half of the spine set with hooked denticles.

The section of this spine—nearly an equilateral triangle—is its most striking feature. It is also more nearly straight than any other species with which I am acquainted.

More than two dozen of these spines were found by Mr. G. K. Gilbert on a slab of sandstone detached from a cliff below the Conglomerate on the banks of Oil Creek. They were mingled with the impressions of many large, flattened and rounded teeth, most of which had been replaced by carbonate of iron, and had lost all definiteness of form and markings. Such a concentration of spines and teeth of Selachians I have nowhere seen; and we may hope that the same bed will hereafter furnish some material of great palæontological interest. It is to be re-

gretted that the teeth which accompany the spines are not better preserved, as they would give us important light on the affinities of at least one of the fishes of which the spines are grouped in the genus *Ctenacanthus*. The obscure impressions left by the teeth indicate a dental series unlike any hitherto known; and if, as seems probable, they belonged to the same fishes that bore the spines, they prove that the genus *Ctenacanthus* includes fishes very different, if not generically distinct.

One of these teeth has somewhat the form of those of *Acrodus*, and might be considered as the tooth of *Orodus;* but the others are more like those of *Psammodus*.

Formation and locality: Waverly group; Oil Creek, Pennsylvania.

Genus GYRACANTHUS, Agass.

Defensive spines of large Selachians, found not unfrequently in the Coal Measures of Europe, and first described by Prof. Agassiz in his "*Poissons Fossiles.*" They are usually straight, and are marked by oblique ridges, which converge ascending, and meet on the anterior margin. These ridges are often broken into tubercles which form a rasp-like surface. Two fine species are described by Prof. Dawson—*G. duplicatus*, D., and *G. magnificus*, D. (Acadian Geology, p. 210, figs. 55 and 55*a*)—from the Coal Measures of Nova Scotia. Of these, one is 22 inches long. The dentition of the sharks which bore these spines is unknown.

Gyracanthus compressus (n. sp.).

Plate 37, Figs. 1, 1*a*, 1*b*, 2, 2*a*, 2*b*.

Spines of large size—12 inches or more in length, 1¼ inches in greatest diameter—laterally much compressed; anterior margin sub-acute; posterior flattened; ornamented portion covered with very numerous, fine, oblique, parallel, pectinated or beaded ridges.

This species of *Gyracanthus* is associated with *G. Alleni*, but is very distinct from that. Its most striking and characteristic features are its flattened, compressed section, and the fine, somewhat reticulated, oblique carination, which covers *all the exposed portion*. *G. Alleni* is more slender, is much more nearly cylindrical, and the oblique ornamentation of the sides is much coarser and is limited to a smaller portion of the surface than in *G. compressus*.

From the foreign species *G. formosus* and *G. tuberculatus* of Agassiz—

probably only varieties of one species—*G. compressus* will be at once distinguished by its flattened section and much finer markings.

Formation and locality: Cuyahoga Shale, Medina, Ohio; and from the Drift (doubtless Waverly), Dearborn County, Indiana.

Gyracanthus Alleni (n. sp.).

Plate 37, Figs. 3, 3*a*, 3*b*, 3*c*, 3*d*.

Spine 6 to 8 inches long, straight, cylindrical below, compressed laterally above; basal portion conical, finely striated longitudinally; line of insertion very oblique, 12°–15°; posterior canal reaching to middle of spine; half of basal portion of exposed surface highly ornamented with oblique, parallel lines of tubercles, which converge and meet on the anterior border; above, these lines of tubercles coalesce, and near the summit form beaded ridges which cover the entire lateral surfaces; posterior half of lateral faces below and posterior face above nearly smooth, but showing fine, oblique striations.

These spines are smaller and straighter than the European species, but exhibit the same generic characters. The distinguishing peculiarity of our species is the great breadth of the nearly smooth posterior belt. In the Old World species this smooth space is altogether posterior, and does not reach the summit of the spine. In our species it occupies half the circumference below, and, gradually narrowing, apparently reaches the summit as a smooth, posterior face.

These specimens are of special interest as being the first of the genus found in the United States; and since *Gyracanthus* is found exclusively in the Coal Measures abroad, they give a decided Carboniferous character to the rock in which they occur.

This species is named in honor of Prof. G. N. Allen, of Oberlin, Ohio, who first met with it. The type specimen is in his cabinet.

Formation and Locality: Cuyahoga Shale (Waverly); Bagdad, and Lodi, Medina County, Ohio.

Genus COMPSACANTHUS, Newb.

Spines of small size, gently curved backward; exposed portion smooth and polished; section at all points circular; a single row of relatively large, remote, depressed hooks set along the posterior median line.

The spines of this genus will be at once recognized and distinguished from all others known by the *single* row of large hooks which they bear along the posterior median line.

Compsacanthus lævis, Newb.

Plate 40, Figs. 5, 5*a*.

Compsacanthus lævis, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Spines small, 3 to 4 inches in length, slender, curved, acuminate, smooth, having a circular section at all points; upper two-thirds furnished with a single row of relatively large, depressed, acuminate hooks, set along the median line of posterior surface, diminishing in size to the summit.

Of this neat little defensive spine quite a number of specimens have been found at Linton, though it is not known to occur in any other locality. The figure now given represents the superior two-thirds of one of these, of the natural size. The basal extremity has not yet been distinctly seen, but it apparently extends considerably below the hooks, and its surface is nearly or quite smooth.

Genus ORTHACANTHUS, Agass.

Orthacanthus arcuatus, Newb.

Plate 40, Fig. 4.

Pleuracanthus arcuatus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Spines 3 to 6 inches in length, 3 to 5 lines in diameter at base, base, gently curved backward, tapering to an acute point; anterior surface rounded, finely striated longitudinally; posterior face flattened, or raised into a low ridge along the median line. This flattened surface occupies about one-third of the circumference, and at the angle formed by the junction of the lateral surfaces with this is, on each side, a row of closely set, acuminate, depressed hooks.

Spines similar to that described above are not uncommon in the cannel coal at Linton, Ohio. They seem to be composed of dense, bony tissue, have a nearly circular section, and show, in the center, traces of a medullary cavity which reaches two-thirds of the way from base to point. At the basal end the opening is apparently terminal. In all essential particulars these spines show a great resemblance to that figured by Agassiz (*Poissons Fossiles*, Vol. 3, Atlas, Tab. 45, Figs. 8, 9), under the name of *Orthacanthus cylindricus*. The specimen so named by Agassiz is not described, but is simply referred to in the text (Vol. 3, p. 330). It is

much larger than any found in Ohio; the two rows of denticles on the posterior face are much more closely approximated than they are in our fossils, and the spine is straight, while ours are gently curved. The latter character exhibited by the specimen in the hands of Prof. Agassiz suggested the name given to it, and there is a certain discrepancy in referring a curved spine to the genus *Orthacanthus;* but the resemblance in the general structure exhibited by the specimens from Linton and that figured by Prof. Agassiz is so close that it seems to me plain they should be united in one genus. If they are generically identical, it simply proves that the discovery of new material has thrown some additional light on the characteristics of the genus, and has shown that the generic name was not fortunately chosen. Among the many spines found at Linton, which are at least generically identical with the one now described, are several which, when they sunk to the bottom of the water inhabited by the fishes which bore them, chanced to fall with the posterior face turned either directly down or up. In such cases, by the vertical pressure to which they have been subjected in the consolidation of the cannel coal, they have been rendered nearly straight; and as the specimen figured by Prof. Agassiz shows many transverse fractures, it is possible that this also was once curved, and, like most dorsal spines of sharks, curved backward. Much more complete and beautiful specimens have been obtained of *O. arcuatus* since the figures now given were made, and one or more of these will be drawn for publication in another volume. In these better specimens the denticulation of the posterior face is most perfectly preserved, and is more regular and beautiful than that of any other spines with which I am acquainted.

At Linton these spines lie in the black coal, and, being coated with sulphide of iron, they have the appearance of beautifully finished and formidable metallic stilettoes. Since they were composed of the densest tissue, they must have formed very effective defensive or offensive weapons.

As we look over the remains of fishes found at Linton to see what other appendages of Selachians exist in corresponding abundance, in order, if possible, to associate them with these spines, we find none but the teeth of *Diplodus*, which, by their numbers, seem to correspond in the slightest degree. The teeth of *Diplodus* are very numerous; and as I have proof from several imperfectly preserved jaws that each fish was provided with several hundred of them, the numbers of the teeth and spines found are perhaps not disproportionate. This relationship is mentioned, not as teaching anything new, but as confirming the conclusions arrived at in the Old World by Sir Philip Egerton and Prof. Kner, viz.: that the spines

called *Orthacanthus* were worn by a Selachian of which the teeth were *Diplodus*.

I should also say that I have recently obtained several specimens in which the spines of *Orthacanthus arcuatus* are buried in the ill-defined mass of granular material which represents in the cannel coal the partly ossified cartilage that composed the hard parts of the head of *Diplodus*. With them are also groups of *Diplodus* teeth still attached to the jaws. These specimens not only confirm the statements made that *Diplodus* and *Orthacanthus* belong together, but also shows that the spines were worn on or near the head.

The specimen now figured (Pl. 40, Fig. 4) is the middle portion of a spine of average size. It is seen from the side, and shows one row of denticles.

Genus DIPLODUS, Agass.

The fish-teeth called by Agassiz *Diplodus* are not unfrequently met with in the Coal Measures of Europe and North America. Two species were described by Agassiz many years ago; *D. gibbosus* and *D. minutus* (*Poiss. Foss.*, Vol. 3, p. 204; Atlas, Vol. 3, Tab. 22*b*, Figs. 4 and 7). Two others are indicated by Prof. Dawson (*D. acinaces* and *D. penetrans*). derived from the roof shales of the coal seams of Nova Scotia (Acadian Geology, p. 211). Three species have been described by myself (Proc. Acad. Nat. Sci., Phila., 1856), *D. latus*, *D. compressus* and *D. gracilis*. These were obtained from the cannel coal at Linton. Two other species were described by Mr. Worthen and myself, *D. duplicatus* and *D. incurvus*, both from the Keokuk limestone of Nauvoo, Ill. Figures and descriptions of the last-mentioned species will be found in the Report of the Geological Survey of Illinois, Vol. II., p. 60, Pl. IV. Descriptions of the two Ohio species which occur in Illinois, *D. latus* and *D. compressus*, and that of another and the most common species found at Linton, are given below. They will be figured in another volume of our Report.

The teeth of *Diplodus* will be at once recognized, wherever found, by their peculiar form. They consist of a rounded or flattened bony base, from which spring two lateral, and sometimes a small central, denticle; the whole being not unlike a miniature representation of the horns of an ox springing from a portion of the skull. They were considered by Agassiz to be the teeth of a Plagiostomous fish, but others have regarded them as dermal spines.* This question has, however, been set at rest by Prof. Kner

* See the paper of Messrs. Hancock and Atthey, in Ann. and Mag. Nat. Hist., May, 1868.

and Sir Philip Egerton, who have shown that they formed the dentition of the sharks of which the spines have been described under the names of *Orthacanthus* and *Xenacanthus*. My own observations confirm those of the last-mentioned authors, as I have several more or less perfect jaws thickly set with the teeth of *Diplodus*. These show that each jaw bore several hundred teeth, arranged in radiating rows, the points projecting inward, precisely as in many modern sharks, and as in the extinct genus *Cladodus*.

As the spines of *Orthacanthus* found at Linton are distinct from the European species, they furnish additional evidence that our species of *Diplodus* are different from those described by Prof. Agassiz.

Diplodus compressus, Newb.

Diplodus compressus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*
Diplodus compressus, N.; Geol. Surv. Ill., Vol. II., p. 60, Pl. IV., Fig. 2.

Teeth from 3 to 6 lines in length; base small; lateral denticles unequally spreading, compressed, with acute points and sharp, strongly crenulated edges; central denticle very small, acute, compressed, finely crenulated on margins.

This is by far the most common species at Linton, where it occurs literally in thousands. It may be recognized by its flattened cornua, of which the edges are salient and conspicuously crenulated. In form these teeth resemble those of *D. latus*, but they are much smaller, and have a flattened, crenulated median denticle which is wanting in that species. From *D. gracilis* they differ in their broader and more flattened cornua, but it is possible these species will be found to run into each other.

Formation and locality: Coal Measures; Linton, New Lisbon and Straitsville, Ohio.

Diplodus gracilis, Newb.

Diplodus gracilis, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Teeth varying in size from 2 to 6 lines in length; base very small; lateral denticles long, curved, slender, divergent toward the points, very slightly compressed, the crenulation of the lateral edges slight or obsolete; median denticle small, subulate, scarcely crenulate.

This is perhaps only a variety of *D. compressus*. It is, however, noticeably more slender, the cornua more rounded, and less distinctly crenulate. They are also less divergent and more curved.

We shall be able to determine the relations of these different forms, only when we shall have found jaws of *Diplodus* which carry all the dental series. On these we may perhaps see that the teeth of the central and lateral rows differ in size and form, as they do in many modern sharks. The specimens which I have already obtained do not, however, indicate any such differences, but they are too incomplete to be decisive of this question.

Formation and locality: Coal Measures; Linton and New Lisbon, Ohio.

Diplodus latus, Newb.

Diplodus latus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*
Diplodus latus, N.; Geol. Surv. Ill., Vol. II., p. 59, Pl. IV., Figs. 1 to 1*e*.

Teeth from 10 to 16 lines long, from 6 to 12 lines broad; lateral denticles ovoid or lance-form, divergent on the same plane, of nearly equal length, acute, compressed, with sharp and strongly crenulated margins; middle denticle obsolete or reduced to a simple knob; bony base tuberous, large, sometimes with a prominent tubercle.

This is a large and strong species of *Diplodus*, not uncommon in the Coal Measures of Illinois, but rather rare in Ohio. It may be recognized by its large size, its broad, flattened, lance-head cornua, divergent in the same plane, and by the absence of a middle denticle.

Formation and locality: Coal Measures; Linton, Ohio.

Genus LISTRACANTHUS, N. and W.

Spines small, gently arched, flattened, thin; sides marked by numerous sharp, longitudinal carinæ; edges set with many divergent, slender, acute teeth, those on the convex margin most numerous and largest; base abruptly expanded and obliquely truncated.

The above name was given by Mr. Worthen and myself to certain small, flattened, strongly striated spines found in the Coal Measures of Illinois. A description of the genus and one species is contained in the Report of the Geological Survey of Illinois, Vol. IV., p. 371. Since the organization of the Geological Survey of Ohio, two or three small specimens of the species found in Illinois (*L. hystrix*) have been obtained from the bituminous shales overlying one of the lower coals in Coshocton County.

Listracanthus hystrix, N. and W.

Listracanthus hystrix, N. and W.; Geol. Survey of Illinois, Vol. IV., p. 372, Pl. II., Figs. 3, 3*a*.

Spines small, thin, delicate, flattened, gently arched in outline, rapidly narrowed above, truncate, and slightly expanded at base; both edges set with sharp, spiny teeth, directed upward; the sides marked with fine, longitudinal ridges, which successively terminate above in the margin.

A few specimens of this small, highly ornamented spine have been procured from the bituminous shales of the Coal Measures of central Ohio, and a much larger specimen was found many years ago, by Dr. S. P. Hildreth, in the Upper Coal Measures near Marietta. Figures of these will be prepared for another volume of the Report. Meantime this peculiar fossil may be readily identified by the description now given.

As I have shown in the Report of the Illinois Geological Survey, these spines are apparently modified scales, and were evidently set *upon the surface* of the body or head, and attached by the broad, trumpet-mouthed bases.

GANOIDEI.

CROSSOPTERYGIDÆ.

Genus CŒLACANTHUS, Agassiz.

The name *Cœlacanthus* was first proposed by Agassiz for certain equal-tailed, hollow-spined fishes from the Magnesian limestone of Durham, England. He subsequently briefly characterized several species of the genus coming from the Carboniferous and Mesozoic rocks of the British Islands and the continent of Europe. He also grouped these with *Holoptychius*, *Undina*, *Macropoma* and several other genera into the family *Cœlacanthi*. These fishes have been since more fully illustrated by Prof. Huxley in the Decades of the Geological Survey of the United Kingdom, so that we have now before us, in the three last-mentioned genera and *Holophagus*, one of the most remarkable and well-defined families of fossil fishes.

Prof. Huxley has shown that *Holoptychius* and several other genera included by Agassiz among his "Cœlacanths," differ somewhat widely in structure from *Cœlacanthus;* and though placed by Huxley in the same sub-order, they are excluded from his family *Cœlacanthini.*

The most noticeable points in the structure of *Cœlacanthus* are very briefly as follows. The fossil fishes of the family *Cœlacanthini* are included by Prof. Huxley in his sub-order *Crossopterygidæ*, or those in which the paired fins are lobed, *i. e.*, have fleshy and scaled bases and centers. In all the Cœlacanths, however, the fins are but slightly lobed, and it is even doubtful whether this character can be said to belong to them. Hence, if included among the *Crossopterygidæ*, the fishes which compose this family constitute a remarkably distinct section, of which the relations to the typical Crossopterygians can only be accurately determined when we shall be in possession of more material than we now have. In *Cœlacanthus*, as in the other genera of the family to which it belongs, the fishes are covered with imbricated, ornamented scales. The head-plates are also ornamented. They have two dorsal fins supported on palmated interspinous bones, and the vertebral column is prolonged centrally through the equi-lobate caudal fin, and bears at its extremity a minute supplemental caudal. The vertebral column was cartilaginous; but the neural arches and the fin-rays were bony. The under side of the head was protected by a pair of long-elliptical jugular plates. The teeth are rarely discoverable, but in the largest specimens of *Cœlacanthus* they are of considerable size, are conical and acute. Prof. Huxley states that in *Cœlacanthus*, as in *Undina* and *Macropoma*, the air-bladder was ossified; but I have not yet discovered any trace of this in the specimens of *Cœlacanthus* which have passed through my hands.*

Until recently, *Cœlacanthus* was without representative in the collections of American fossil fishes; but when the remarkable fish-deposit of Linton was discovered, species of this genus were found to be more abundant there than in any other known locality. The finding of *Cœlacanthus* at Linton, a place so far removed from those in which it occurs abroad, is not only a fact of much geological interest, but, since the most common species found there is scarcely distinguishable from *C. lepturus* of the Coal Measures of England, it affords another and interesting illustration of the homogeneity and wide distribution of the Coal Measure fauna, and the remarkable persistence in space, as well as time, of even minute characters in the organization of *Cœlacanthus*.

Prof. Huxley has called attention to the very great resemblance, and almost generic identity, of *Cœlacanthus*, *Undina* and *Macropoma;* and cites this succession of fishes—the inhabitants of ages to our compre-

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* A very interesting and instructive review of the relations of the genus *Cœlacanthus* will be found in Decade XII. of British Fossils, published among the Memoirs of the Geological Survey of the United Kingdom.

hension infinitely removed from each other—as affording a striking example of what he terms a persistent type. In this case we have a form of organization showing an elaborate and complicated structure, which has continued almost unchanged throughout the inconceivable duration of successive geological ages, while all the world of physical circumstance was revolutionized again and again. The extension of *Cœlacanthus* into America affords another instance of the wide diffusion of forms which have great vertical range.

Cœlacanthus elegans, Newb.

Plate 40, Figs. 1, 1*a*, 1*b*, 1*c*, 1*d*.

Cœlacanthus elegans, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body fusiform, robust, 6 to 8 inches in length; cranial surface covered with closely approximated tubercles; surfaces of opercula, mandibles and jugular plates ornamented with raised lines, generally continuous, but sometimes broken into detached tubercles. On the opercula these lines radiate from the superior angle. On the mandibles and jugulars they are imperfectly parallel with the margins of these plates. Scales nearly circular, exposed portion ornamented with converging raised lines; anterior dorsal fin slightly in advance of ventrals; posterior dorsal as much forward of anal fin. Radial formula, A. D. 10; P. D. 12; C. 22; A. 6; V. 11.

Among several hundred specimens of *Cœlacanthus* which I have obtained from Linton, it has not been easy to decide whether there was more than one species. Nearly all of these specimens are of about the same size, *i. e.*, from six to eight inches in length; the operculum having the longest diameter of about half an inch; the jugular plates, one inch. I have obtained, however, many fragments of very much larger individuals, some of which must have attained a length of a foot and a half. I also have one small and slender specimen which presents some characters which, I have supposed, might be of specific value. I have, therefore, described three species, giving to the more common one the name of *C. elegans;* to the largest, *C. robustus;* and to the smallest, *C. ornatus.* Future observation will alone determine how constant the distinctions are upon which the species have been founded. Another question not yet cleared of doubt is, whether our most common species, *C. elegans*, is distinct from *C. lepturus* of Agassiz, from the Coal Measures of Europe. The differences between them are certainly not great, and I shall not be

surprised if they should ultimately prove to be inseparable. Unfortunately, no specimens of the foreign species are before me; but on comparing our fishes with the excellent figures given by Prof. Huxley, I notice that in *C. lepturus* the ornamentation of the jugular plates is much more transverse than in any American specimen I have seen. In size, form, and general character of ornamentation of the body, no well-marked differences are discoverable. A careful comparison of specimen with specimen will alone enable us to decide this question; and yet it probably has no practical importance. The resemblance between the American and foreign fossils is so close that we are compelled to ascribe to them a common origin; and if slight differences shall be found to exist between them, it will be doubtless wiser to consider the two forms as varieties of the same species rather than as specifically distinct.

The figures now given of *C. elegans* are very imperfect, but they will suffice for the identification of any specimens which may be in the possession of the readers of this Report. In another volume some additional illustrations of this species will be published, and such as will afford better means of comparing the American and European fishes.

Formation and Locality: Coal Measures; Linton, Ohio.

Cœlacanthus ornatus, Newb.

Cœlacanthus ornatus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Fishes of small size, not exceeding 4 to 5 inches in length; body fusiform, slender, scarcely wider than head; cranial plates ornamented with relatively large and remote tubercles; opercula, mandibles and jugular plates marked with elevated lines, which, like those on the scales, are stronger than in the associated species.

More material will be required before we can decide whether the specimens described above constitute a distinct species of *Cœlacanthus*. They present, however, some features which have led me to separate them from all others found in the same locality, viz.: a more slender and cylindrical form of body, and stronger ornamentation of the scales and cephalic bones. This ornamentation is not only relatively, but absolutely, coarser than that of *C. robustus*, in individuals ten times as large. No illustrations of this species are given in the present volume, but figures will be published hereafter.

Judging from the representations of *Cœlacanthus elongatus*, Hux. (Mem. Geol. Surv. Unit. King., Dec. XII., Pl. V., Figs. 6, 7), it seems to me

probable that Prof. Huxley had before him specimens of this species when his description was written. Further comparisons, however, will be necessary before this question can be decided.

Formation and Locality: Coal Measures; Linton, Ohio.

Cœlacanthus robustus, Newb.

Plate 40, Figs. 2, 2*a*.

Cœlacanthus robustus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body robust, 1 foot to 1 foot 6 inches in length; upper surface of cranium covered with small, closely approximated tubercles; opercula, mandibles and jugular plates threaded with fine, parallel, sometimes interrupted lines; opercula 1 inch 6 lines in longest diameter; jugular plates 2 to $2\frac{1}{2}$ inches in length, 6 to 8 lines wide; extremities pointed, sometimes acute; teeth conical, acute, smooth, longest 2 lines in length; scales elliptical in outline, exposed portion ornamented with fine, converging, raised lines.

Of the great number of specimens of *Cœlacanthus* which are before me, nearly all are less than eight inches in length, and these are so uniform in size that I have supposed that their dimensions were those of mature individuals of one species, *C. elegans*. We have occasionally, however, met with fragments, and in one case an entire, though decomposed, individual of a much larger *Cœlacanthus*. Of these larger fishes no specimen has been obtained sufficiently well preserved to furnish the materials for a detailed description. All the generalities of structure and ornament are apparently the same in the larger and the smaller individuals; but in the strength of ornamentation on the scales and bones there are no differences corresponding to the difference in size; the thread lines and tubercles of the largest species being, indeed, less strongly marked than in some of the smaller ones. I have, therefore, been led to conclude that the large individuals belong to a distinct species, which I have designated by the name given above. In this conclusion I am strengthened by the uniformity of size which prevails among the specimens of *C. lepturus* of Europe, which is so closely allied to our *C. elegans*. Not having any specimens of *C. robustus* sufficiently complete to furnish a good drawing, I now publish figures of only a jugular plate and a scale, natural size.

Formation and Locality: Coal Measures; Linton, Ohio.

Rhizodus lancifer, Newb.

Plate 39, Fig. 9.

Rhizodus lancifer, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Teeth striated below, section elliptical, smooth toward the summit, where they are very much compressed, with a lenticular section and cutting edges; summit of tooth like a lance head; near the apex the cutting edge of one side is often slightly gibbous, an apparent tendency toward a barbing of the point, as is seen in the teeth of *Lepidosteus*. As usually found, the plicated base of the tooth has mostly disappeared, the solid point alone remaining; this is about an inch long. The entire tooth was more than twice that length.

Teeth similar to that now described are not unfrequently met with in the Coal Measures in different parts of our country; but so far as I know, always detached from their connections with the jaw. Large fish-scales, such as are usually referred to the genus *Rhizodus*, often occur with them, and both are usually supposed to belong to the same animal. It has been suggested, however, that these so-called *Rhizodus* teeth are really the teeth of Amphibians; and it is not improbable that this may be true of some of them. The large scales, however, with which they are associated (such as *R. quadratus*, Pl. 39, Fig. 8), are unquestionably the scales of fishes; and Ganoids of sufficient size to wear such scales, probably had jaws furnished with teeth as large as these. Future discoveries will doubtless give us the information we so much desire in regard to these interesting fossils; and the researches necessary to answer the questions suggested will perhaps be stimulated and aided by the publication of the material we now have, fragmentary though it be.

Formation and locality: Coal Measures; Linton, Ohio.

Rhizodus angustus, Newb.

Plate 39, Fig. 6.

Rhizodus angustus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Laniary teeth elongated, slender, finely striated at base, smooth above, with cutting edges, length one inch; subordinate teeth less than half the length of the larger ones, with a circular section throughout, slender, acute, striated; surfaces of jaw coarsely tubercled.

In the diversity of form in the teeth, this species differs from *R. gra-*

cilis, McCoy, as well as from other species found in Ohio. As has been remarked in regard to the other large flattened teeth associated with these at Linton, it is by no means certain that they represent the dentition of fishes. Some of the Amphibians, of which the remains are found in the same deposit, are so like the Ganoid fishes in structure, that it is impossible to say, without having more complete material, to which group these teeth belong.

Rhizodus quadratus (n. sp.).

Plate 39, Fig. 8.

Scales large and thin, largest 2 inches long by $1\frac{3}{4}$ wide, imperfectly quadrangular in outline; surface nearly smooth, but margins marked by fine radiating striæ and concentric lines of growth; central and posterior portions marked by fine thread-like reticulations.

I have given the above name to certain large and thin scales which are found in the cannel coal at Linton, and which belong to some large fish that may be supposed provisionally to be a species of *Rhizodus*. They resemble in their general character those found by Dr. Hibbert in the Burdie House limestone, but are undoubtedly specifically distinct. These may be the scales of the fish of which the teeth are named *Rhizodus lancifer*, but they have never been found in connection.

Genus MEGALICHTHYS, Agassiz.

Rhombiferous Ganoids of large size; head defended by strong, bony, highly polished plates; jaws furnished with numerous small conical teeth and a few large laniary teeth striated at base, and resembling those of Saurians; the vertebræ are ossified, the paired fins are supposed to be lobate, and the body is covered with rhomboidal enameled scales, of which the surface is punctate and brilliantly polished.

The remains of *Megalichthys* are frequently met with in Europe, where, from its great size, its powerful dentition, and its coat of mail, it must have been the tyrant of the bays and lagoons of the Coal Measure epoch. No traces of *Megalichthys* are reported to have been hitherto found in America, but I have for some years had in my possession scales and vertebræ obtained from the Coal Measures of Ohio, which must have belonged to fishes of this genus. Two of these scales are represented on Plate 40, Figs. 3, 3*a*. They are generally rhomboidal in form, each side 6 to 9 lines in length, are thick and strong, and are covered with a bril-

liant coating of brown punctate enamel. The under surface of these scales is elliptical in outline, about 10 lines in diameter, and exhibits the concentric lines and sub-central umbilicus, which are so characteristic of the under side of large Ganoid scales. These scales were found in the black shale overlying Coal No. 5, at Mineral Point, Tuscarawas County, Ohio. From the cannel coal of Linton I have obtained a number of short, massive, bony, amphicœlous vertebræ from 6 to 8 lines in diameter, scarcely distinguishable from the vertebræ of *Megalichthys* sent me by Mr. Barkas, and obtained from the shales of the Northumberland coal field, England. These, so far as I know, are the first traces of this great Carboniferous Ganoid met with in this country.

The material before me is too meager to enable me to say with certainty whether ours is a new species of *Megalichthys*, and it is probably best to leave that question to be decided by future discoveries.

I should perhaps mention in this connection, that the large, *thin* scales—sometimes 4 or 5 inches in diameter—found in the Coal Measures of England and Scotland, and formerly attributed to *Megalichthys*, are now known to belong to *Rhizodus*.

LEPIDOSTEIDÆ.

Genus PALÆONISCUS, De Blainville.

A genus of rhombiferous Ganoids included in Owen's order *Lepidoganoidei* and family *Palæoniscidæ*, and a type-genus of Huxley's family of *Lepidosteidæ*, of which *Palæoniscus*, *Amblypterus*, *Eurylepis*, etc., are Carboniferous genera. *Palæoniscus* includes twenty or more species, ranging from the Sub-Carboniferous limestone to the Trias. They have fusiform bodies, rhomboidal scales, heterocercal tails, a single dorsal fin, fulcral spines on the anterior margins of all the fins. Their teeth are numerous, conical, and acute. In some species the scales are highly ornamented, in others plain and polished. It was formerly supposed that the Carboniferous species generally had plain scales, while those of the Permian were striated. This is now known to be incorrect, as most of the Carboniferous species have ornamented scales and head-plates. In Europe several species of *Palæoniscus* are quite common in the Carboniferous and Permian strata, and most cabinets contain specimens of *P. Frieslebeni*, which occurs so abundantly in the Permian copper schists of Mansfeld. In America several species have been described from the Carboniferous rocks of New Brunswick, and one, *P. fultus*, from the Trias of the Con-

necticut valley. In Ohio two species only have been found in such a degree of preservation as to admit of description, *P. peltigerus* and *P. Brainerdi*, both of which are noticed in this volume. In the iron-stone nodules of Mazon Creek, Illinois, a very small species (*P. gracilis*, N. and W.) has been obtained by Mr. Worthen. Fragments of larger species, not yet described, have been met with in the same locality, in the Waverly at Knob Lick, Ky., and in the Cleveland shale—the base of the Waverly —in many parts of Ohio, and at Vanceburg, Ky. In the Cleveland shale the smooth, shining, rhombic scales of *Palæoniscus* are found wherever the stratum is opened; but, up to the present time, no entire individual has been seen. In the fish-bed at Linton *Palæoniscus* is far outnumbered by *Cœlacanthus* and *Eurylepis*, but the species found there is the most highly ornamented known; in this respect vieing with any of its associates, though they all exhibit a profusion and delicacy of ornament quite unknown among the fishes of the present day. Perhaps the taste for color was not developed in these ancient fishes; but if sexual selection created all the elaborate ornamentation of their polished armor, they certainly had a highly cultivated sense of beauty in form. Since, however, sexual selection so little controls the propagation of fishes, the elaborate system of ornament exhibited in the adornment of our palæozoic fishes becomes somewhat difficult of explanation by the Darwinian hypothesis.

Palæoniscus peltigerus, Newb.

Plate 38, Figs. 1, 1*a*, 1*b*.

Palæoniscus peltigerus, N.; Geol. Surv. Ill., Vol. II., p. 17.
Elonichthys peltigerus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body short, compressed; length, 5 inches; height, 1 inch 4 lines; surface of cranial bones covered with small, thickly-set tubercles; maxillaries and mandibles ornamented by parallel convolutions of thread lines; scales all covered with similar raised lines, which cross them diagonally downward and backward, terminating in serrations of the posterior margins. About the middle of the space between the occiput and dorsal fin, on the median line, begins a row of large, oval, ornamented scales, extending to the dorsal fin. Behind the dorsal is a similar row, which become transformed into large, striated fulcra, which overlie the prolongation of the vertebral column to its termination. Fins large; dorsal triangular, nearly an inch in height and the same in breadth, composed of about 26 rays; ventrals lower, but as broad, and contain-

ing nearly the same number of rays; pectorals oblong, rounded at extremity, composed of about 10 rays; anal fin extending from ventrals to caudal, containing 40 or more rays; caudal broad as anal, and apparently composed of an equal number of rays.

This is a highly ornamented, and must have been a beautiful species of *Palæoniscus*. It was apparently an inhabitant of many of the lagoons of the coal marshes of North America, as I have received it from several places in Ohio, Indiana and Illinois. It is possible, also, that it will prove to be identical with some one of the species described by Dr. C. T. Jackson, and obtained from the Albert mine in New Brunswick. I have some imperfect specimens from that locality of a species very closely allied to this, in which, however, the ornamentation of the scales is coarser. Judging from Dr. Jackson's descriptions and figures, it would seem that *P. peltigerus* differs from the smaller species found at the Albert mine, in having the scales on the sides relatively higher, the markings finer and more oblique, and in the larger size of the fins. From his larger species it differs in its higher scales and finer and more oblique markings. The ornamentation is apparently more general and elaborate in our species than in any of the Albert mine fishes. It resembles them, however, in many respects, and belongs to the same group of species with them and *P. decorus* of Sir Philip Egerton.

Formation and locality: In Cannel Coal, at Linton, Jefferson county, and Canfield, Mahoning county, Ohio; Coal Measures of Fulton county, Illinois, etc.

Palæoniscus Brainerdi, Thomas.

Palæoniscum Brainerdi, Thomas; Cleveland Times, Sept. 14th, 1853.

Fish 12 inches in length, fusiform, slender; body covered with relatively small, rhomboidal scales, which are finely and diagonally striated; dorsal fin set opposite the anterior margin of anal; both these fins triangular, 1 inch 3 lines in height and breadth; caudal fin 3 inches in length, superior lobe very much produced.

A short, popular description of this fish was given by Mr. W. H. B. Thomas in a Cleveland newspaper, and subsequently in the Report of the Polytechnic Institute of Philadelphia. I have since received numerous specimens of it from Mr. Hannibal Goodale, of Chagrin Falls, Ohio, in whose quarries in the upper layers of the Berea grit it occurs. Mr. Goodale has been careful to preserve all that have been found in working his quarries, but most of these have been given away and scattered, so

that no good ones have been accessible for figuring in time for this volume. It is hoped that material will be obtained from which better illustrations and a more complete description can be given, in another volume, than it is now possible to furnish.

The species was named by Mr. Thomas in honor of Prof. J. Brainerd, of Cleveland, who obtained the first specimens, and called the attention of geologists to the interesting locality where it is found.

Formation and locality: The only locality where *P. Brainerdi* is known to occur is in the upper layers of the Berea grit at Chagrin Falls, Ohio.

Genus EURYLEPIS, Newb.

Heterocercal Lepidoganoids of small size; body fusiform; head obtuse; tail elongated, lobes very unequal; fins small and provided with delicate fulcra; dorsal fin opposite anal or nearly so, both set far back on body; ventrals near middle of abdomen; cranial surface ornamented by corrugations, tubercles or granulations; maxillary, mandibular and jugular plates ornamented with convoluted corrugations of the surface in various patterns; scales smooth or ornamented, posterior margins of lateral scales all or in part serrated, scales of median line above and below characteristically angled or toothed, two or more rows of scales on sides extending back to near anal fin, remarkably high, vertical 2 to 5 times longitudinal diameter; lateral line nearly straight, passing through the upper part of the lower row of the high lateral scales; teeth numerous, conical, short.

The peculiar group of fishes to which I have given the name of *Eurylepis*, mainly replace *Palæoniscus* in the ichthyic fauna of the locality where they occur. From *Amblypterus* and *Elonichthys* they may be readily distinguished by their small fins, all bearing fulcra. With *Palæoniscus* their affinities are closer, but the *ensemble* of characters presented by the large number of specimens which I have examined, seems to separate them from that genus. Among these diagnostic characters, the most conspicuous are their small size, posterior position of dorsal fin, and especially the high lateral scales. The large median scales of the back, so common in *Palæoniscus*, are wanting in all the species of *Eurylepis* which have come under my observation.

In the lagoon that existed at Linton in the peat-marsh where Coal-seam No. 6 was forming, these little fishes must have been exceedingly numerous. In some parts of a mine opened there, this coal-seam shows a thin stratum of cannel at its base; and hardly a fragment of this can-

nel can be found which does not contain the detached scales of *Eurylepis*. Sometimes, indeed, several individuals, in a more or less perfect state of preservation, will be seen in a block a few inches square. It is evident also that they formed a large part of the subsistence of the many carnivorous fishes and salamanders which inhabited the same water. This is indicated by the great number of coprolitic masses found in the cannel, and which are sometimes almost entirely composed of the scales of *Eurylepis*.

As I was the first to discover the fossiliferous character of the cannel at Linton, and have been collecting during twenty years from this locality, a large number of good specimens of *Eurylepis* have come into my possession. Among these I have found marked differences in the size and form of the body, in the shape of the scales, and in the degree and kind of ornamentation of the scales and cranial plates. These differences have led to the creation of several species, but their distinctive characters can only be clearly seen where there is much good material in hand for comparison, and when that material is carefully scrutinized. In such circumstances, however, it will not be difficult to show that the differences I have indicated are quite as real as those which have been considered sufficient to separate the species of *Palæoniscus* from each other. Whether some of these distinctions are not dependent upon age or sex we have not yet ascertained; but, since the characters that have served to distinguish the species are such as are usually regarded as having specific value, there has seemed to be no other way than to give them this value until such time as they may be found to shade into each other, and thus obliterate specific lines.

In the most complete specimens of *Eurylepis* found, the exoskeleton may be said to be perfect. The ornamented cephalic bones, the scales, and the fin-rays, are all in position, without a fracture or displacement. In all cases, however, the scaly armor of the fish alone remains. The cartilaginous portion of the cranium, the vertebral column, and the neural and hæmal spines, have entirely disappeared.

It may be regarded as somewhat remarkable that such a group of fishes as is formed by the several species of *Eurylepis* should be found in abundance in one locality, and no one of them have been met with elsewhere. It will be remembered, however, that over the immense area occupied by Carboniferous rocks in the United States, careful search for the remains of fishes has been made in but few of the places where such fossils would be likely to occur. Doubtless as the working of our coal mines progresses, and as the local geology of our Carboniferous districts is more thoroughly worked up, very great additions will be made to our

knowledge of the fishes which lived on our continent in that far-off age. As yet only five localities have yelded any considerable number of Carboniferous fishes in this country, viz.: the Albert mine, New Brunswick; the banks of Mazon Creek, Grundy County, Illinois; the quarries of the Berea grit at Chagrin Falls, the Cleveland shale at Vanceburg, Ky., and the Niesly mine at Linton, Ohio. In each of these localities fishes are found which have not been collected elsewhere. For example, none of the species of *Palæoniscus* of the Albert mine, of Chagrin Falls or Mazon Creek have been obtained in any other places than those I have enumerated, and none are common to two of these. The same may be said of *Eurylepis* and *Cœlacanthus*, and also of the various Amphibians found at Linton. At Mazon Creek we have procured *Platysomus* and *Amblypterus*, but they have been obtained in no other American locality. And yet these are genera so characteristic of the Coal Measures of Europe, that now, since we have found them in one place, we may expect them to be met with in many others. The species of *Cœlacanthus* most common at Linton (*C. elegans*) is as abundant as any species of *Eurylepis*, but not an individual of the genus has been found any where else in this country.

These instances of the recurrence, even in single localities in America, of the Carboniferous fishes of Europe, prove so general a distribution of both genera and species, that we shall be sure to meet with them again and again.

It should be remembered, also, that the little fishes found in the Coal Measures were inhabitants of circumscribed bodies of water—rivers, lagoons, lakes and bays—and therefore their distribution could not have been so general as that of marine, and especially of pelagic fishes. We can only hope to find such groups of lagoon-inhabiting fishes as those of Linton when we chance to come upon the sediments of the perhaps few and remotely-set pools of open water in the coal marshes. Since, however, we have learned that our cannel coals and the bituminous shales associated with our coal seams are the sediments which accumulated in the bottoms of these lagoons, our search need not be entirely at random. Such localities as Linton—where the cannel coal is *crowded* with animal remains—must necessarily be rare; but I am led by my own experience to expect that similar fossils, though, perhaps, in less numbers, will be discovered in various parts of our country. In Europe the bituminous shales of the Coal Series, the beds of cannel and the concretions of nodular iron ore have yielded most of the scaled fishes of the Coal Measure epoch, and we may expect that our experience in America will be the same.

Eurylepis tuberculatus, Newb.

Plate 38, Figs. 2, 2*a*, 2*b*, 2*c*, 3, 3*a*.

Eurylepis tuberculatus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body fusiform; entire length 3 inches; head 6 lines; tail 8 lines; cranial plates strongly tuberculated; tubercles rounded, elongated or reniform; surfaces of opercular, maxillary and jugular bones covered with linear, parallel corrugations; scales of the body smooth, except a few on the anterior dorsal and ventral surfaces, which are sometimes punctate; lateral scales nearly 5 times as high as long, posterior margins bearing a few serrations; anal fin opposite dorsal.

This is perhaps the most common species of *Eurylepis* at Linton. It may be recognized by its tuberculated cranium (much more distinctly tuberculated in the figure 2*c*) and by its high, smooth, polished scales, conspicuously serrated on their posterior margins.

Eurylepis corrugatus, Newb.

Plate 38, Figs. 4, 4*a*.

Eurylepis corrugatus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body fusiform, robust; length 3 inches 4 lines; breadth 10 lines; length of head 8 lines; anterior lateral scales $2\frac{1}{2}$ times as high as long; cranial plates ornamented by convolutions of fine, thread-like corrugations; maxillary bones, opercular and hyoid plates corrugated much as superior surface of head; scales smooth, except a few on the anterior dorsal surface, which are finely striate and punctate; posterior margins of lateral scales as far back as anal and dorsal fins serrated; scales of tail, like most of those of the dorsal and ventral surfaces, plain on surface and margins; anterior margin of anal fin opposite center of dorsal; longest rays of anal when collapsed just reaching base of caudal.

This is the largest and most robust species of the genus yet known. It may be identified by the relative vertical shortness of the lateral scales, which are smooth, and especially by the convolutions of thread lines which cover all the cephalic bones.

Formation and locality: Coal Measures; Linton, Ohio.

Eurylepis ovoideus, Newb.

Plate 39, Fig. 1.

Eurylepis ovoideus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Fish small, robust; body ovoid; length 1 inch 6 lines; breadth 6 ines; length of head 4½ lines; cranial surface corrugated and finely granulated; sides and lower parts of head ornamented by thread-like corrugations; scales of anterior portion of abdomen granulated, of sides serrated; lateral scales 3½ times as high as long.

Of this small species I have obtained a large number of specimens. It is usually broader and more ovate in outline than would be inferred from the figure. Its distinguishing characteristics are the mingling of tubercles and thread lines in the cephalic ornamentation, and the relative height of the lateral scales. In form and marking it approaches nearest to *E. corrugatus*, but in that the head is not tubercled and the lateral scales are relatively shorter.

Formation and locality: Coal Measures; Linton, Ohio.

Eurylepis insculptus, Newb.

Plate 39, Fig. 2, 2*a*.

Eurylepis insculptus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body fusiform, slender; length 2 inches 6 lines; breadth 5 lines; cranial plates ornamented with elongated tubercles, spaces between tubercles granulated; sides and under surface of head marked by raised lines and fine granulations; scales on anterior half of the body highly ornamented; lateral scales 3½ times as high as long, and having a double waved line along anterior margin, with acicular denticulations of posterior border; scales of abdomen having entire surface covered with appressed denticles; scales of tail and posterior portion of body plain; dorsal fin opposite anal.

This highly ornamented species approaches in its markings that next described, *E. ornatissimus*, and they may prove to be merely varieties of the same. The distinction visible in the specimens before me is this: that in *E. insculptus* only those scales which are on the abdomen and anterior portion of the body are ornamented, while in *E. ornatissimus* the surface of every scale is roughened with salient points.

Formation and locality: Coal Measures; Linton, Ohio.

Eurylepis ornatissimus, Newb.

Plate 39, Figs. 4, 4*a*.

Eurylepis ornatissimus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Fish small, fusiform, slender; length 2 inches; breadth 5 lines; cranial surface sparsely tubercled, tubercles somewhat radiated; spaces between tubercles finely granulated; lateral and inferior bones of head granulated and corrugated; all the scales of the body and tail ornamented with granulations, striæ or denticles; lateral scales 4 times as high as long, with a double line of appressed denticles on anterior borders and acute serrations of posterior margins; fins all relatively longer than in other species; dorsal fin nearly opposite anal.

This little fish is elaborately ornamented in every part, and presents the extreme form of the tendency to adornment which runs through all the genus. I have felt compelled by the differences noted in the descriptions of *E. insculptus*, *E. granulatus*, and *E. ornatissimus*, to consider them as specifically distinct. But their great general resemblance suggests the possibility that they may prove to be varieties only.

Formation and locality: Coal Measures; Linton, Ohio.

Eurylepis granulatus, Newb.

Plate 39, Figs. 5, 5*a*.

Eurylepis granulatus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body fusiform, robust; length 3 inches, breadth 7 lines; head 6 lines long; tail 9 lines; head tubercled above, tubercles elongated, with granulations between; lateral and inferior bones of the head threaded; scales apparently thinner and more delicate than those of any other species; those on the anterior portion of the body granulated, and having a faint, double waved line along anterior margin; posterior border serrated; lateral scales 4 times as high as long. Radial formula, D. 6; C. 14; A. 8; V. 5?; P. 9?.

As has been remarked, this species considerably resembles the two preceding, but in a large number of well-marked specimens which I have before me, the characters are so constant that I am inclined to regard the species as a good one. This is one of the more common forms.

Formation and locality: Coal Measures; Linton, Ohio.

Eurylepis lineatus, Newb.

Plate 39, Figs. 7, 7*a*.

Eurylepis lineatus, N.; Proc. Acad. Nat. Sci., Phila., *loc. cit.*

Body fusiform, robust; length 3 inches, breadth 8 lines; cephalic bones all ornamented with thread-like lines, as in *E. corrugatus*, and without tubercles; scales of anterior portion of abdomen covered with concentric thread lines; margins of lateral scales ornamented in the same manner; lateral scales lower than in any other species yet discovered, greatest vertical diameter scarcely twice longitudinal; scales of abdomen very numerous and twice as long as high.

In this well marked species we find an absence of the high scales of the sides which form so striking a feature in most species of the genus. It would, therefore, if considered separately, be generally regarded as a *Palæoniscus;* but the peculiar ornamentation of the head-plates, the posterior position of the dorsal fin, and the absence of the large nuchal scales of *Palæoniscus*, seem to require that it should be made generically distinct and united with the other species of *Eurylepis*. This is the rarest of all the forms found at Linton.

Formation and locality: Coal Measures; Linton, Ohio.

Eurylepis minimus (n. sp.).

Plate 39, Fig. 3.

Fishes very small, 8 to 12 lines long, 2 to 4 lines wide; cranial surface corrugated with short, curved, obtuse ridges, with a few tubercles at the nasal extremity; maxillaries, lateral and inferior head-plates ornamented with relatively coarse, parallel, raised lines; scales on inner surface nearly smooth; exteriorly, somewhat roughened by obtuse knobs or arches; lateral scales $3\frac{1}{2}$ to 4 times as high as wide; posterior margin delicately serrate.

The cannel coal at Linton contains immense numbers of minute fishes, from $\frac{3}{4}$ of an inch to 1 inch in length, which I, for a long time, supposed to be the young of the different species of *Eurylepis* with which they are associated. I have been led, however, to doubt whether this is the case, as they exhibit such a remarkable uniformity of size, and their markings seem to be somewhat different from those of any of the larger species. I have now in my possession several hundred specimens which vary but

little in dimensions and markings, and there is no such gradation in size between these and the individuals of the species of *Eurylepis* that have been described, such as we might expect to find if one were the fry of the other. It is true, also, that a few individuals of the most common species of *Eurylepis* (*E. tuberculatus*) have been found at Linton, which are much smaller than the average, and which evidently represent the earlier stages of growth of that species; but they are distinguishable from even the largest of *E. minimus* by their thicker, smoother scales, and the broader and rounder tuberculation of the cranial surface.

It may seem surprising, if we consider the species now described as distinct from all the larger ones, that so few young individuals of those should be found where the mature forms are so abundant. But the same thing is true in regard to *Cœlacanthus*. The more common species of this genus, *C. elegans*, is, perhaps, as frequently met with at Linton as any species of *Eurylepis;* and yet, out of the great number which I have obtained there, only two specimens were very much below the average size. It seems probable, therefore, that the young of both *Cœlacanthus* and *Eurylepis*—as is the case with so many of our living fishes—had different feeding grounds from those of the mature individuals.

Among the hundreds of specimens of *E. minimus* which are before me as I write, a very considerable number are smaller and narrower than the others; and in these the head-plates and scales seem to have been exceedingly thin and delicate, so that they are now warped and corrugated, giving the impression, at first sight, that they are highly ornamented. I am inclined to believe, however, that these are only younger individuals of *E. minimus* in which the plates and scales were so very thin that they have been corrugated simply by pressure.

The figure now given of *E. minimus* presents only the general aspect of the fish, and no effort has been made to copy the markings of the cranial plates. The specimen drawn was also somewhat imperfect, and the nasal extremity of the head is not represented. In more complete specimens the head is seen to be obtuse, the eye orbit relatively large, and almost always distinctly visible. Highly magnified views of the different plates and scales are required in this, as in the other species of the genus, to give a clear idea of the character and beauty of their ornamentation. Perhaps these anatomical details will be given in a future volume of the Report. The mission of the figures now published will be fully accomplished, however, if through them, the more conspicuous features of this new and interesting group of fishes are made known, and they afford the means for identifying the species described.

Formation and Locality: Coal Measures; Linton, Ohio.

Eurylepis striolatus (n. sp.).

Fishes of small size, from 1 to 2 inches in length by 3 to 5 lines in width; form robust; head rounded and obtuse; cranial surface tuberculated; lateral and inferior head-plates ornamented with parallel, raised, interrupted, sometimes beaded or granulated lines; lateral scales 5 times as high as wide; all the scales of the anterior portion of the body ornamented with fine, straight, thread-lines, which run from front to rear, and cover the posterior two-thirds—probably all the exposed portion—of each scale. These lines are parallel among themselves; about nine on the highest scales.

Of this little fish I have but few specimens, but these are so clearly marked as to leave no doubt that they are specifically distinct from any others yet described. In general form they resemble the larger individuals of *E. minimus*, and some of them are scarcely larger. They are, however, somewhat more robust, the posterior portion of the body broader, the upper lobe of the tail shorter; but none of these characters would alone serve to distinguish these from the hundreds of other little fishes with which they are associated. The markings of the scales, however, are altogether different from those of any other species of *Eurylepis*, and the fine, widely spread, straight, thread-lines that traverse them from front to rear will arrest the attention at the first glance at the fish with a lens. The posterior margins of the scales seem not to be serrated, but they are perhaps slightly crenulated by shallow scallops between the raised lines. No figure of this species is given in the present volume, as the specimens described were not obtained in time. It will probably be figured hereafter.

Formation and locality: Coal Measures; Linton, Ohio.

GEOLOGICAL SURVEY OF OHIO.

VOL. I. PART II.

PALÆONTOLOGY.

SECTION III.

DESCRIPTIONS OF FOSSIL PLANTS.

BY

BY J. S. NEWBERRY.

DESCRIPTIONS OF FOSSIL PLANTS

FROM

THE COAL MEASURES OF OHIO.

Comparatively few of the fossil plants obtained from the Coal Measures of Ohio are described on the following pages. Several hundred species have been collected, many of which are new to science, and of these descriptions and drawings of quite a number have been prepared; but of most of these it has been thought best to defer the publication for the present. This volume of the Report is mainly devoted to the strata and fossils of the Silurian and Devonian systems and to fossil fishes.

Our fossil fishes are derived from both the Devonian and Carboniferous systems, but the largest and most interesting forms are from the Devonian. As it seemed to me desirable that this group of vertebrates should be considered as a whole, a general review of the fishes found in our rocks is given on the preceding pages.

Our fossil plants are for the most part found in the Carboniferous strata, yet some very interesting ones are furnished by both the Silurian and the Devonian systems. I have thought that the fossil plants should somewhere be discussed together, and, so far as practicable, the history of plant life in the different geological ages should be traced out, and the relations of our fossils plants to each other and to other fossil floras should be made the subjects of investigation. A memoir which should have this character and be similar in its scope to that now published on our fossil fishes, would, as it seems to me, have considerable interest and value; and I have intended to prepare something of the kind for our Reports. This work has been deferred, however, for the present, and precedence has been given to the discussion of our fossil fishes. This arrangement has seemed to be the natural one, inasmuch as our study of the geology and palæontology of the State has been progressive, from the older to the newer formations.

In our next volume on palæontology the invertebrate fossils of the Carboniferous will be described and figured, and that will also contain a memoir by Prof. Cope on the fossil salamanders of the Coal Measures. In that volume the general discussion of our fossil flora will naturally find place. The descriptions of *all* our fossil plants would have been deferred until they could be presented together, but this would have thrown the larger amount of material into our second volume. To divide this material more evenly, therefore, as well as to give variety to the contents of this volume, a few of our fossil plants are now figured and described. Most of the space alloted to these is taken up by the descriptions of such fruits and seeds as have been obtained from the Coal Measures. These form a group of genera and species of which the relations to the other portions of the coal flora are somewhat obscure, and they can therefore with some propriety be made the subjects of a special memoir. To these are added a few ferns of special interest, of which those who are students or collectors of fossil plants will be glad to have descriptions as early as possible.

Genus POLYSPORIA, Newb.

The above name has been chosen to designate certain cones which are sometimes found in the roof-shales of Coal No. 1, in Summit and Mahoning Counties. When well preserved—which is rarely the case—they are seen to be composed of a central woody axis, from which radiate, spirally, a large number of cylindrical or clavate sporangia, filled with minute, discoidal—once spherical—spores. Oftener than otherwise the cones are much crushed and broken; the sporangia being detached from the axis, and forming a matted and irregular mass. Not unfrequently, too, the spores have burst their capsular sporangia, and are scattered thickly through the adjacent shale.

The individual sporangia are club-shaped, rounded at their distal extremities, where crucial or transverse marks are frequently to be seen. These marks I have supposed to indicate the position of sutures where the sporangia opened at maturity to permit the escape of the spores.

No connection has ever been observed between these singular groups of seed-vessels and the plants to which they were originally attached; we are, therefore, driven to an examination of their minute structure for a clue to their botanical relations. Here the conclusions attained are only general, and are not such as will permit us at present to refer them to even the genus of plants of which they formed the fruit. Composed, as they are, of sporangia and spores, and attaining so considerable dimen-

sions, we are safe in considering them the fruit of an acrogenous tree, but whether of Lycopod or fern, it is scarcely possible to decide.

The fruit of the *Lycopodiaceæ* forms a cone of some sort, having a central woody axis, from which radiate, spirally, bracts or scales, of which the shield-like extremities form an imbricated, external surface, concealing and protecting the seeds within. These seeds consist of spores, contained in capsular sporangia, borne by the pedicel which supports the scale. The fruit before us, however, while it had a cone-like form and a woody axis, shows no imbricated scales; but, instead, naked, club-shaped sporangia, inserted directly upon the axis. This is not *very* unlike the style of fructification of some ferns; such, for example, as have a distinct fertile frond consisting of capsules or sporangia of various forms and variously grouped, and containing numberless minute spores. Among our common ferns, *Onoclea* and *Botrychium* may be cited as examples of the group whose fructification forms clusters of spore-bearing capsules. There is no fern known to me, however, of which the fructification forms a massive cone at all like that before us. The cones of the living Lycopods are also far removed from this, both in size and structure, but the fruit-cones of some of the fossil *Lycopodiaceæ* approach considerably nearer to it. Most of the cones of the gigantic extinct Lycopods—*Lepidodendron*, *Lepidophloios*, *Sagenaria*, etc.—are several inches in length, and, like the cones of *Lycopodium* and *Selaginella*, consist of a woody axis, supporting horizontally-radiating bracts, each of which bears upon its upper surface one or more sporangia filled with spores (microspores or macrospores, sometimes one, sometimes both). In *Polysporia*, we have the same woody axis, but no bracts; the sporangia having thick and strong walls, and being so closely set that they occupy all the circumference of the axis, and form a solid, cylindrical fruit-cone. This structure is evidently such as would require the plant which bore this fruit to be separated generically from the cone-bearing Lycopods which I have enumerated above. In all of these, so far as known, the cones are largely composed of bracts, and the sporangia are as closely covered and well protected as are the seeds of the pine or fir. Doubtless at maturity the cones opened, so that the spores might escape, but at an earlier period the sporangia must have been entirely concealed.

In the cones called *Lepidostrobus* the sporangia are large, oblong or cylindrical in form, each occupying the entire length of the horizontal portion of the bract that sustains it, and only microspores are contained in those of all parts of the cone.

In *Flemingites*, each bract of the cone sustains a number of relatively small sporangia, which, as in *Lepidostrobus*, contain only microspores.

In *Triplosporites*, the sporangia are large and simple, as in *Lepidostrobus*, but they contain microspores above and macrospores below.

When, now, we compare the cone of *Polysporia* with these, we see that it agrees with *Lepidostrobus* in the character of its sporangia and spores, but differs from it widely in the absence of bracts. In a cone which has been called *Lepidostrobus Dabadianus* by Schimper*—but which, containing microspores and macrospores, should rather be considered as a species of *Triplosporites*—the form and general aspect are much more like those of *Polysporia* than any of the other fossil cones heretofore described. In this, too, the bracts are shorter and more slender, the sporangia forming a relatively greater portion of the mass of the cone. If in this cone we could imagine the bracts still further dwarfed, until finally the ends of the sporangia should be exposed, and form a tesselated surface, we should have *Polysporia*, in all repects save this, that it has only, so far as observed, microspores in the sporangia.

It will be seen from the above description that, as has been stated, in general structure *Polysporia* most resembles the fructification of the great Carboniferous Lycopods; and while the peculiarities it exhibits are plainly sufficient to exclude it from any genus yet described, the characters it has in common with *Lepidostrobus*, *Triplosporites* and *Flemingites* seem to require that it should be included in the same family with them.

Polysporia mirabilis (n. sp.).

Plate 41, Figs. 5, 5*a*, 6.

Cone, 3 inches in length by 1½ inches wide, consisting of a series of club-shaped sporangia, thickly set upon a central axis and filled with minute spores; each sporangium, of which there are, perhaps, a hundred in each cone, three-fourths of an inch in length, rounded at its remote extremity, narrowed, and sometimes necked or wedged at its proximal end. The sporangia are filled with microspores, many hundreds being contained in each. They are flattened and discoid as fossilized, but were originally spherical. They are often marked with three salient, radiating lines.

Formation and locality: Roof of Coal No. 1; Tallmadge, Summit County, Ohio.

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* Paleontologie Vegetale, Tom. II., p. 69, Pl. LXII., Figs. 1–12.

Antholithes priscus, Newb.

Plate 41, Fig. 3.

Antholithes priscus, N.; Annals of Science, Vol. II., p. 2 (1854).

Flower-stem smooth, somewhat flexuous; bearing six or more flowers? placed alternately—the lower ones nearly opposite—in the axils of bracts; flowers? pendulous, bases and peduncles covered with scales.

No detailed description of this interesting fossil is required, since all its more important characters are given in the figure now published. It is plainly the florescence of some plant; and although the component parts of flowers cannot be distinctly made out, and it is by no means certain that the organs which still remain ever formed or surrounded a conspicuous corolla, still the specimen possesses a certain grace and beauty which almost warrants us in believing that it was once a spray of flowers, such as form the greatest charm of the vegetation of the present day. The stem which supports these floral organs is perfectly smooth, and is now so much flattened that it is evident it could never have been composed of solid woody tissue. It would only be necessary for any one to see the specimen to be satisfied that it was never a branch of a tree with scaled buds or catkins; but it was a tender and perhaps succulent stem which had for its sole function the support of the florescence of the plant which bore it. In two instances I have found the flowers? which are here attached separated from the stem and expanded in a disk upon the shale. Under such circumstances they present very much the appearance of some composite flower with its scaled involucre compressed vertically.

In the remarks which will be made on the genus *Cardiocarpon*, I shall refer to this specimen and the circumstances under which it was found. On Plate 41, figures 1, 2 and 4 represent some fruit and flower stems found with that which I have described. These were accompanied by great numbers of the leaves and stems of *Cordaites*—most of the former being flabellate, and different from the most common species—and I have been led to conjecture that all these belonged to the same plant; and that in *Antholithes* we had the florescence of *Cardiocarpon*, and that *Cardiocarpon* was the fruit of *Cordaites*. Future discoveries will doubtless prove or disprove this conclusion, and it is manifestly wiser to leave the solution of the question to time, than to attempt to enforce it by arguments drawn from the imperfect material at our command.

Formation and locality: Shale over Coal No. 1; Youngstown, Ohio.

Genus TRIGONOCARPON, Brongt.

Fossil nuts, of an ovoid form, marked with three salient longitudinal lines, have been found in the Coal Measures, in greater or less abundance, in every country where rocks of this age occur. These nuts were grouped in the genus *Trigonocarpon*, many years ago, by Brongniart. Since that time they have been collected in great numbers, but in no case have they been found attached to the tree or plant on which they grew; so that their affinities with other members of the coal flora remain a matter of doubt, and have been the subject of much discussion among fossil botanists. As generally preserved, all details of anatomical structure have disappeared. Most frequently, indeed, the fossil consists of a cast in sandstone of the nut, stripped of its integuments and more or less worn and broken. In a few instances they have been found better preserved, and such have been described by Dr. Hooker and Prof. Dawson. By both these gentlemen a general resemblance in structure between these nuts and the fruit of some of the Conifers and Cycads has been noticed, and the "Gingko" (*Salisburia*) has been cited as bearing a fruit containing a nut not unlike them. As will be seen further on, my own observations throw some additional light upon the fruit of which *Trigonocarpon* is the nut.

I have said that up to the present time the nuts under consideration have never been found connected with the plant which bore them. This is the more surprising as they occur in such profusion. In the roof-shales of Coal No. 1, in Summit County, I have seen literally hundreds within the area of a few square yards, and they are not unfrequently so well preserved there as to show the entire form of the drupaceous fruit with its rind or epicarp unbroken. This proves that they had not been transported, but had accumulated with twigs and leaves under the trees on which they grew. With these nuts are the *debris* of various coal plants, viz.: the trunks and branches of *Lepidodendron*, the trunks and leaves of *Sigillaria*, the leaves of *Cordaites*, countless fern fronds, *Calamites*, *Asterophyllites*, *Sphenophyllum*, *Annularia*, etc. Among all these are none which have been regarded as Conifers. The *Coniferæ* were well represented in the Carboniferous flora, as we know, and the highlands of the Carboniferous continent were undoubtedly clothed with forests of pine-like *Araucariæ*. But these did not grow in the coal marshes, and contributed little or nothing to the formation of coal itself. We seem, therefore, to be compelled, in tracing the parentage of *Trigonocarpon*, to make choice among the well known elements of the coal flora. The fruit

of *Lepidodendron* is a cone, like that of *Lycopodium*, and has often been found attached to the tree. The fructification of the Calamites and of their allies *Asterophyllites*, *Sphenophyllum*, etc., as well as that of the ferns, is also well known. There remain, therefore, only two common coal plants of which we can consider *Trigonocarpon* the possible fruit, *Sigillaria* and *Cordaites*. Fossil botanists have discussed the relations of *Sigillaria* at considerable length, without, however, reaching any universally accepted conclusion. Prof. Dawson considers them Gymnosperms, while Mr. Carruthers regards them as distinctly cryptogamous, and more nearly allied to the Lycopods than to the Conifers. My own observations confirm those of Prof. Dawson in regard to the structure of the trunk of *Sigillaria*. The outside was evidently composed of a thick cortical integument, to which the leaves were attached. Within this was a mass of cellular tissue, surrounding a slender woody axis, with a relatively large medullary cavity. This is very unlike the structure of the trunk in most of our Conifers, but is not very dissimilar to that of the trunk of Cycads. The probabilities are that the *Sigillariæ* formed a group of plants considerably unlike any now living, and such as served to connect the Gymnosperms with the Acrogens. If this was their botanical position, it would not be at all surprising if we found that they possessed a trunk sharing the peculiarities of the Sago-palms and tree-ferns, bearing drupaceous fruits not unlike those of the Cycads and some of the infinitely varied *Coniferæ*. If we compare the fruits of *Pinus*, *Taxus*, *Salisburia* and *Ephedra*, among the *Coniferæ*, we shall discover such a latitude of structure as will prepare us to accept the association of the fruit *Trigonocarpon* with the trunk *Sigillaria* without much hesitation.

In regard to *Cordaites*, I think we have good proof that it is not, what it has sometimes been considered, a fern, but was more nearly allied to the Cycads than to any other living plants. In another place, I shall give my reasons for associating *Cordaites* with the Cycads, and for considering *Cardiocarpon* as its fruit. I should have no difficulty in considering *Trigonocarpon* as the fruit of *Cordaites*, were it not that I have found *Cardiocarpon* more directly connected with it, and that in some localities where *Trigonocarpon* is abundant, the remains of *Cordaites* are rare or absent, and *vice versa*.

We know that *Sigillariæ* were the most common trees in the forests of the Coal period, and that the tissues of their trunks and leaves contributed largely to the formation of coal. Hence their fruit or seed-vessels must be abundant in the coal or roof shales of our coal seams. As all the other fruits and seeds, except *Trigonocarpon*, that are frequently met with in the Coal strata are satisfactorily connected with the plants

that bore them, and *Sigillaria*, equally abundant, is without known fruit, until something more than circumstantial evidence is obtained, I shall be disposed to regard *Trigonocarpon* as the fruit of one or the other of the very different and, perhaps, generically distinct groups of trees now included in the genus *Sigillaria*. Goldenberg has described and figured a very different form of fruit as that of *Sigillaria*. He represents it as consisting of small sporangia, borne on the bases of modified leaves; but I am compelled to say that in many years spent in collecting fossil plants from strata where *Sigillariæ* abound and are well preserved, I have never seen such a form of fructification as that described by Goldenberg.

Whatever plants bore these nuts as fruit, it is evident that they grew in clusters on deciduous fruit-stalks; probably much as the palm-nuts grow at the present day. If they had been borne on the twigs of a branching plant, we should be quite sure to find them still connected with some fallen branches, broken off by wind or lightning-stroke; the immature fruit adhering firmly, under such circumstances. We may conclude, therefore, that they sprang from the trunk, borne by delicate sprays, to which no leaves were attached; almost never falling except at maturity, and generally each by itself, though sometimes dropping in clusters, but with no appendages that could give a clue to their former connections. One of these days, a tree, fallen in full leaf and fruit, will be discovered in the roof of some coal mine, displayed in all its length, from root to summit. This will show the clusters of fruit still attached to the parent stem, and thus solve the long mystery.

On Plates 42 and 43 will be found several figures which exhibit the entire fruit of which *Trigonocarpon* is the nut. These show that it was ovoid or elliptical in outline, with a smooth, leathery rind. In some specimens the contained nut is entirely concealed (Pl. 42, Fig. 10, Pl. 43, Fig. 12); in others its outlines are brought out by pressure in the shales (Pl. 42, Fig. 9, and Pl. 43, Fig. 15). Most of the specimens obtained from the sandstones are more or less beach-worn and marred. Occasionally, however, one is found—like that represented on Plate 42, Fig. 1—which has suffered little injury beyond the loss of the fleshy envelope. In this and some others I have seen, the three conspicuous salient ridges which traverse the surface longitudinally, are shown to be the remains of broad and delicate wings; so delicate that they are generally all torn away, with the exception of their thickened bases. In the argillaceous shales overlying the beds of coal, we find not only the entire fruits which I have described, but detached portions of the external skin or coating bearing the impression of the stem at the base, of the flower above. The latter is sometimes a six-rayed star, such as we might suppose would be left by the fall of a six-parted flower (Pl. 42, Figs. 5 and 6).

Those who have collected the fossil nuts so abundant in our coal shales will have noticed that portions or fragments of the shells of *Trigonocarpon* are much more abundant than the complete nuts; and they will have noticed, too, that the shell has often separated in thirds, each third presenting an elliptical or lenticular arched surface, bordered by the projecting wings, which, more or less perfectly preserved, form a more or less complete margin to the arched side of the nut. Such specimens as these have been described as distinct species of either *Rhabdocarpus* or *Carpolithus*. Abundant examples prove to me, however, that they are but portions of the shells of *Trigonocarpon*, which seem to have divided naturally through the salient angles or wings, very much as the external envelope of the hickory nut divides. This is well shown in Plate 43, Fig. 14, where a portion of a slab, covered with the remains of a cluster of nuts, is represented. In this group, with innumerable irregular fragments of the shell and external rind, many segments of the shell, such as I have described, are visible; also several nuclei or kernels which they once enclosed (*a*, *b*, segments of shell; *c*, *d*, nuclei).

Trigonocarpon triloculare, Hildreth.

Plate 42, Figs. 1, 13, 13*a*; Plate 43, Fig. 13.

Carpolithus trilocularis, Hild.; Amer. Jour. Science, 1st. Ser., Vol. XXXI., p. 29, Fig. 4.
Trigonocarpon Hildrethi, Lesqx.; Geol. of Pennsylvania, Vol. II., p. 877.

Nut ovoid, sometimes nearly spherical, marked with three salient ridges which pass from base to summit. These ridges are the remains of prominent wings, which, in a few rare instances, are preserved. When present they unite above and form a long, triangular point, as in Plate 42, Fig. 1. The surface of the nut between the wings is smooth. Within the shell is contained an ovoid nucleus, of which the surface is reticulately marked (Fig. 13*a*).

This is the most common species of *Trigonocarpon* found in the Conglomerate of Northern Ohio. I have, also, obtained it from the heavy-bedded sandstone over Coal No. 1. As will be seen in the figures now given, this species sometimes attains large size—2 inches in length by $1\frac{1}{2}$ in diameter—almost reaching the dimensions of *T. magnum*. But it differs from that species in having but three salient ridges. From *T. Bertholletiforme*, another large species which occurs higher up in the Coal Measures, it may be distinguished by its broad, ovoid, or spherical form.

This is undoubtedly the nut described by Dr. Hildreth in his "Miscellaneous Observations during a Tour to the Falls of the Cuyahoga," 1835, (Amer. Jour. Sci., Vol. XXXI).

Formation and locality: Conglomerate and Lower Coal Measures; Summit and Mahoning Counties, Ohio.

Trigonocarpon tricuspidatum (n. sp.).

Plate 42, Figs. 2 to 6.

Nut elliptical in outline, rounded below, narrowed above into a neck-like prolongation, which is expanded into a three-pointed area. From these points three salient ridges are prolonged downward nearly to the base of the nut, where they become obsolete. As was probably the case with all other species of *Trigonocarpon*, this nut was surrounded by a drupaceous envelope, covered with a leathery rind.

The nucleus or kernel contained within the shell was elliptical in form, having the surface marked with reticulating lines.

On Plate 42, Fig. 2, is given a representation of the complete nut without its envelope; Figs. 3 and 4 represent the kernel; Figs. 5 and 6 portions of the leathery integument.

Formation and locality: Roof Shales of Coal No. 1; Tallmadge, Ohio.

Trigonocarpon ornatum (n. sp.).

Plate 42, Figs. 7, 7*a*.

Nut elliptical in outline; 1 inch in length by $\frac{3}{8}$ of an inch wide; constricted above into a neck, which is expanded into a stellate, six-rayed, cupped area at the summit. From the points of this area six sharp, keel-like ridges are prolonged to near the base of the nut, where they become obsolete. Of these ridges three are the more prominent, three lower ones alternating with these. The elliptical or fusiform outline of this elegant little nut, its stellate summit and six sharp and prominent keels, will enable any one to distinguish it at a glance from any other described species.

The figures given represent side and end views, of the natural size.

Formation and locality: Carboniferous Conglomerate; Cuyahoga Falls, Ohio.

Trigonocarpon multicarinatum (n. sp.).

Plate 42, Figs. 8, 8*a*.

Nut of small size, 9 lines long, 6 lines wide; rounded below, truncated and cupped above; the surface marked by about 21 longitudinal ridges, of which three are more prominent than the others. These ridges give a crenulated margin to the cup at the top. The three most prominent ridges are prolonged from the margin to the raised centre of the cupped summit, dividing it into three nearly equal divisions.

Formation and locality: Carboniferous Conglomerate; Cuyahoga Falls, Ohio.

Trigonocarpon magnum (n. sp.).

Plate 42, Figs. 11, 11*a*.

Nut ovoid or elliptical in form, large, $2\frac{1}{2}$ inches in length by $1\frac{3}{4}$ in width; surface marked by six salient ridges running from base to summit; spaces between the ridges smooth, and, at the base of the nut, rising into prominent arches between the depressed bases of the salient ridges.

This is the largest species of *Trigonocarpon* of which I have any knowledge. The only specimen I have of it I owe to the courtesy of L. V. Bierce, Esq., of Akron, Ohio, who obtained it from the Coal-measure sandstone near Coshocton, Ohio.

Trigonocarpon Bertholletiforme, Foster.

Plate 42, Figs. 12, 12*a*.

Trigonocarpon Bertholletiforme, Foster; Annals of Science, Vol. I., p. 128 (1853).

Nut long-ovoid in outline, rounded and obtuse at base, acute at summit; section trigonal; the angles marked by ragged salient ridges. In general appearance it resembles the Brazil nut, the fruit of *Bertholletia excelsa*.

Of this nut I have seen no specimen, and the only one known to Col. Foster was that from which his drawings, now copied, were made. These seem, however, to indicate differences from any other known species, which will be readily appreciated by those who may discover other specimens. The most striking features in this nut are its large size, elongated form, trigonal section and strong ridges running from base to summit.

Formation and locality: Upper part of Lower Coal Measures; Guernsey County, Ohio.

Carpolithus fragarioides (n. sp.).

Plate 43, Figs. 2, 2*a*.

Nucleus spherical or transversely elliptical in outline, about half an inch in diameter; in the fossil state very much flattened, though doubtless originally nearly spherical; surface marked with a kind of net-work of smooth bands, with areoles which form a double spiral. These areoles were apparently more prominent than the separating bands, so that the nut must have had somewhat the aspect of the strawberry with its prominent achenia. External envelope apparently drupaceous, contained in a leathery rind.

This peculiar fruit is found in the shales over Coal No. 1, but is quite rare. The figure given of the nucleus (2*a*) conveys a very imperfect idea of the marking of the surface. The figure of the external envelope (2) shows the appearance it usually presents—torn open, and the nucleus having escaped. I am, perhaps, in error in supposing that these two fossils are portions of the same fruit; but they are so associated in one locality as to render it almost certain that they belong together. Further observation will doubtless clear this question of any doubt now hanging over it, and will perhaps reveal something in regard to the botanical relations of a fruit which is so unlike anything hitherto found in the Coal Measures.

Formation and locality: Shales over Coal No. 1; Mill Creek, near Youngstown, Ohio.

Genus CARDIOCARPON, Brongt.

This is the name given by Brongniart to certain flattened, more or less heart-shaped seed vessels, found in the Coal Measures of all countries. The fruit consists of a central nucleus, often beautifully heart-shaped, surrounded by a margin which forms, sometimes a lower copy of the nucleus, sometimes an annular band enclosing the nucleus, but is oftener more or less deeply notched at the summit; while in a remarkable species, *C. samaræforme*, from the roof of the lowest coal in Summit County, the margin forms two broad lobes or wings, which give the fruit much the aspect of the winged seeds of the maple. Nearly all species of *Cardiocarpon* show a distinct point of attachment at the broad end of the nucleus, and, unlike *Trigonocarpon*, they are never found enclosed in an endocarp. Usually the entire fruit, nucleus and margin of *Cardiocarpon*,

forms a smooth, thin carbonaceous wafer, and it is quite evident that it was originally thin and flat.

Though very abundant in the roof shales of some of the coal strata, especially of the lowest, *Cardiocarpa* have never been found united to the plants which bore them. Hence their relation to the other coal-plants with which they are associated is a matter of conjecture, but I have been led to suspect that they may be the fruits of *Cordaites*. From their abundance in the coal shales, it is evident that they must have belonged to some plant which grew abundantly in the coal marshes, and could not have been connected, as has been suggested, with some unknown plant inhabiting the distant uplands. In one instance, only, I have found *Cardiocarpa* attached to stems. These stems had been detached from the plant on which they grew, but were so mingled with the leaves and stems of *Cordaites* as to afford strong presumptive evidence that they belonged together. In the same association were numerous specimens of *Antholithes*, so that I have been led to suspect that these are the flowers or immature fruit of *Cardiocarpon*. On Plate 41, I have given figures of *Antholithes* and *Cardiocarpa*, all from the same locality and found in juxtaposition, and it is possible that they may represent but different phases of the fructification of *Cordaites*.

In another place I shall have something to say about the botanical relations of *Cordaites*, and I will only remark here, in passing, that in an interesting suite of specimens which I obtained in the locality that furnished a large number of *Antholithes* and *Cardiocarpa* (specimens 1 to 4 on Plate 41, and a great number beside), were stems of *Cordaites* which showed both their external surface and internal structure. These lead me to class this plant with or near the Cycads, and it requires no great stretch of imagination to suppose that such a plant had flowers and fruit similar to *Antholithes* and *Cardiocarpon*. The resemblance between the seed vessels we call *Cardiocarpon* and the fruit of *Cycas revoluta*, e. g., is very striking, as may be seen by a comparison of Figs. 1 and 8, Plate 43. Here in Fig. 1 we have the entire fruit of the recent *Cycas*, the nucleus it contains being represented beside it; while in Fig. 8 we see a common form of *Cardiocarpon*. If the fruit of our *Cycas* were strongly compressed, the outline of the nucleus it contains would become visible, and we should have almost an exact copy of Fig. 8. It is apparent, however, that *Cardiocarpon* was always flatter than the drupe of *Cycas revoluta;* but this is a "mere matter of detail." In general structure, so far as we know, the fruits I have compared are very much alike; enough so, at least, to encourage further consideration of the question now proposed. It may be objected that if we accept the fruit or flower spikes

called *Antholithes* as the flowers of *Cardiocarpon* and *Cordaites*, we must imagine the florescence of *Cordaites* to have been different from that of *Cycas*—different not merely in form, but in structure and function. In the modern *Cycadæ* the flowers are diœcious, but the grouping suggested would require that the florescence of *Cordaites* should be monœcious or hermaphrodite. This objection, however, has little weight, as we see great variation in this respect in the same family—the Palms, for example—and there may very well have once been hermaphrodite Cycads, though in the living forms the sexes are separated. Hermaphroditism would seem to be a simpler and earlier mode of florescence. Diœcious and monœcious flowers are generally regarded as examples of differentiation, though as results of natural selection, quite incomprehensible to me. To my mind the chances of fertilization would seem to be diminished in the ratio of the square of the distance to which the male and female organs were separated.

The theory has been advanced by some botanists that *Cardiocarpon* is the fruit of *Lepidophloios*, but unless we are grossly mistaken, this latter plant was a Lycopod, and I can hardly imagine any modification of *sporangia* which would resemble *Cardiocarpon*.

Cardiocarpon latum, Newb.

Plate 43, Fig. 3.

Cardiocarpon latum, N.; Annals of Science, Vol. I., p. 153 (1853).

Nucleus broad, heart-shaped, flat, smooth, sharply acuminate, marked with a cicatrix at base, and surrounded, except at the basal cicatrix, with a narrow margin, terminating, like the nucleus, in a sharp point at the summit. A fine line runs from the apex of the nucleus to the summit of the margin.

Formation and locality: Roof of Coal No. 1; Cuyahoga Falls, Summit County.

Cardiocarpon minus, Newb.

Plate 43, Fig. 4.

Cardiocarpon minus, N.; Annals of Science, *loc. cit.*

Nucleus ovate, acuminate, smooth, from 4 to 6 lines in length, marked by a small cicatrix at base, and by a short, elevated line which passes through the apex, extending about 1 line toward the base; margin entirely surrounding the nucleus, conforming to its outline, broadest at the summit.

Formation and locality: In bituminous shale, immediately below Coal No. 1; Cuyahoga Falls, Summit County.

Cardiocarpon elongatum, Newb.

Plate 43, Fig. 5.

Cardiocarpon elongatum, N.; Annals of Science, *loc. cit.*

Nut small; length 6 lines, width 3 lines; nucleus ovoid, acuminate, 3 lines long, flat, smooth, with cicatrix at base, entirely surrounded by a margin which is very narrow at the base, is much prolonged beyond the apex of the nucleus, and terminates in a rounded summit, which is sometimes emarginate. A line passes from the summit of the margin into the apex of the nucleus.

Formation and locality: In shale over Coal No. 1; Youngstown, Ohio.

Cardiocarpon bicuspidatum, Sternb.

Plate 43, Figs. 9, 9*a*.

Carpolithus bicuspidatus, Sternb.; *Flora der Vorwelt*, I., t. 7, f. 8.

Nucleus transversely elliptical or reniform, flat, smooth, abruptly acuminate, without cicatrix at base, surrounded by a very narrow margin, which is broadest at the summit. This is probably the species figured by Sternberg, although I have never seen a specimen from this vicinity which was bicuspidate. As he has given no description with his figure, it is impossible to determine whether his species is the same with ours. Both evidently belong to the genus *Cardiocarpon*.

Formation and locality: Roof shale of Coal No. 1; Tallmadge, Ohio.

Cardiocarpon marginatum, Foster.

Plate 43, Fig. 7.

Cardiocarpon marginatum, Foster; Annals of Science, Vol. I., p. 129 (1853).

Outline of fruit ovoid-oblong, rounded above, apiculate at base, 8 lines long, 6 lines wide; nucleus ovoid, 4 lines long, 3 lines wide, marked by a salient line running from the acute apex to the base of the fruit; margin entirely surrounding nucleus, broadest above.

Of this species of *Cardiocarpon* I have never seen a specimen, but the figure and description given by Col. Foster prove it to be quite distinct from any of those found by myself in Northern Ohio. The figure now given is a copy of the drawing made by Col. Foster.

Formation and locality: Lower Coal Measures; Zanesville, Ohio.

Cardiocarpon annulatum, Newb.

Plate 43, Figs. 8, 8*a*.

Cardiocarpon annulatum, N.; Annals of Science, *loc. cit.*

Nucleus heart-shaped, or short-ovoid, acuminate, 6 lines in diameter, flattened, faintly striate; marked at base by the cicatrix of the pedicel; surrounded by an annular margin of nearly equal breadth, which is sometimes slightly emarginate at the summit. This species resembles *C. emarginatum*, Goepp. and Berger, but differs from it in the absence of the emargination of the border at the base, and in the slight, often obsolete, emargination of the apex.

Formation and locality: In shale over Coal No. 1; Youngstown, Ohio.

Cardiocarpon orbiculare, Newb.

Plate 43, Fig. 10.

Cardiocarpon orbiculare, N.; Annals of Science, *loc. cit.*

Nucleus orbicular, 3 lines in diameter, flat, or a little round, smooth, with a minute cicatrix at base, entirely surrounded by a very narrow border, which is narrowest at the base.

Formation and locality: In shale over Coal No. 1; Cuyahoga Falls, Ohio.

Cardiocarpon retusum, Sternb.

Plate 43, Fig. 6.

Carpolithus retusus, Sternb.; *Flora der Vorwelt*, I., t. 7, f. 10.

Nucleus heart-shaped, with cicatrix at base, strongly rugose or tubercular, bordered by a very narrow striated margin. Sternberg's figure is more rounded at the apex than our fossil generally is, and is destitute of the striated margin. I have specimens, however, which agree precisely with his figure.

Formation and Locality: In shale over Coal No. 1; Tallmadge, Youngstown and Massillon.

Cardiocarpon samaræforme, Newb.

Plate 43, Figs. 11, 11*a*.

Cardiocarpon samaræforme, N.; Annals of Science, *loc. cit.*

Nucleus round-cordate, flat, 9 lines in diameter, faintly concentrically-striate and reticulate, a fine elevated line running from base to apex; base strongly marked with the cicatrix formed by the detachment of the organs of support and nutrition. Attached to the nucleus are broad, apparently membranous wings, which spring from the cicatrix at the base, encircle the nucleus, becoming broader as they appoach the apex where they meet; from this point they rise, diverging from each other, with a rounded outline, to a height nearly equal to the diameter of the nucleus. Wings distinctly veined, and having a thickening border.

Formation and locality: In shale over Coal No. 1; Tallmadge, Summit County, Ohio.

Genus RHABDOCARPUS, Goepp. et Berg.

This name was given by Goeppert and Berger to certain nuts found in the Coal Measures, and which, with some resemblances to *Trigonocarpa*, differ from them in this—that they are not triangular or tripartite, are more or less flattened, have a lenticular section, are often elongated and pointed above and below, and generally have the surface marked with numerous longitudinal ribs or rods, whence the name. It will be seen, however, by reference to Plate 44, on which several species of this genus are figured, that not all the species which have the general form of *Rhabdocarpus*, agree with Goeppert's generic description, as some of the ovoid, flattened nuts associated with *Trigonocarpa*, and yet clearly distinct from them, are not elongated or pointed, and are without the longitudinal ribs. Very likely these differences represent generic differences in the trees which bore them, but it seems hardly worth while, at present, to attempt any refined classification of these *disjecta membra*. I shall, therefore, include in *Rhabdocarpus* all the ovoid, flattened nuts which do not exhibit the tripartite character of *Trigonocarpon*.

Up to the present time we know too little of the details of structure of these fossil nuts to make it worth while to spend much time in speculations as to their botanical affinities. The trees which bore them were undoubtedly closely allied to those of which *Trigonocarpon* was the fruit, and the general structure of the two groups of fruits was undoubtedly

the same, *i. e.*, the nuts were enclosed in more or less fleshy envelopes, covered with a leathery rind, and containing a kernel, consisting of a mass, in one or two cotyledons of elaborated nutriment stored up for the use of the germinating embryo; all of which is quite different from any known form of fructification among cryptogamic plants. We are compelled, therefore, to look among the Phænogams for the congeners of *Rhabdocarpus* and *Trigonocarpon*. But it is not necessary to look far up the scale of flowering plants before we reach resembling forms. Among the palms are fruits not very unlike these, and among the Gymnosperms, such as *Salisburia*, those that come still nearer. Dr. Hooker compares *Trigonocarpon* with the fruit of the "Gingko," and is inclined to consider the tree which bore the fossil nut a Conifer. For reasons given elsewhere, I am disposed to regard *Trigonocarpon* as the fruit of *Sigillaria*, and, from their similarity of structure, *Rhabdocarpus* must follow *Trigonocarpon* wherever it goes.

Rhabdocarpus carinatus (n. sp.).

Plate 44, Fig. 3.

Nut ovoid in outline, rounded below, somewhat acute above; surface marked by numerous longitudinal, rounded ridges, which become obsolete near each extremity. In some specimens portions of an external envelope, which covered and concealed the ridged shell, are visible.

Formation and locality: Shales over Coal No. 1; Summit and Mahoning Counties, Ohio.

Rhabdocarpus Danai, Foster.

Plate 44, Fig. 4.

Rhabdocarpus Danai, F.; Annals of Science, Vol. I., p. 129 (1853).

Nut oblong, compressed and finely striated; the base obtuse, the apex sharp, terminating in a point; the remains of an elevated line visible at the apex, and of a depressed line extending from the base nearly one-half the length of the nut in the direction of the axis; nucleus surrounded by a broad corrugated margin, in which are visible four or five folds parallel with the margin of the nucleus.

I have seen but a single specimen of this nut, and this is that from which Col. Foster's description was drawn. It is badly fractured and

gives but an imperfect idea of the entire fruit. It is quite certain, however, that it is distinct from any nut before described, and it will be readily recognized, when found, from the figure now published.

Formation and locality: From shales over Coal No. 3; Zanesville, Ohio.

Rhabdocarpus lævis (n. sp.).

Plate 44, Figs. 5 and 5*a*.

Nut 2 inches in length by $1\frac{1}{4}$ wide, ovoid in outline, rounded below, with the central point of the base slightly prominent; constricted but obtuse above; sides equally arched, smooth and polished; section lenticular, with acute edges.

This fine nut, when its broader side is seen, exhibits the ovoid outline and general proportions of the largest specimens of *Trigonocarpon Hildrethi*, but is strikingly different from that, in wanting its three salient ridges, and in its flattened form and lenticular section; its shortest transverse diameter being less than one-half the distance from edge to edge.

Formation and locality: Carboniferous Conglomerate; Cuyahoga Falls, Ohio.

Rhabdocarpus apiculatus (n. sp.).

Plate 44, Fig. 6.

Nut elliptical in outline, rounded below, acute or apiculate at the summit; surface marked by about twelve nearly equal, rounded, longitudinal ridges, which are strongest in the central portion of the nut, and become obsolete near either extremity; length $1\frac{1}{4}$ inches; width $\frac{3}{4}$ of an inch.

Possibly this will prove to be not distinct from *R. costatus*, as we have not yet learned the limit of variability in these groups of nuts; and it is even possible that both these may be but varieties of *R. carinatus*. In the specimens before me, however, marked differences are discernible, and such as, if permanent, would constitute fair ground for considering them specifically distinct. In *R. carinatus*, the form is more elongated, the summit more produced, the longitudinal ridges more slender and numerous, and somewhat grouped in fascicles of three. In *R. costatus*, the form is more nearly circular, the carinæ are much stronger, are acute angled, and alternate stronger with fainter ones; while in the

species under consideration, they are rounded, equally spaced and nearly uniform in strength.

Formation and locality: Over Coal No. 1; Tallmadge, Ohio.

Rhabdocarpus acuminatus (n. sp.).

Plate 44, Fig. 7.

Nut large, $2\frac{1}{4}$ inches in length by $1\frac{1}{2}$ in breadth; broadly ovate in outline; rounded below, acute and long-pointed above; surface nearly smooth, but showing faint traces of longitudinal ridges.

I have thought it possible that this form is but a phase or condition of *R. costatus;* perhaps that nut with the external envelope more or less perfectly preserved. Up to the present time, however, proof of identity is wanting, and the marked differences which are perceptible in the specimens before me seem to require that they be designated by distinct names.

Formation and locality: Roof shales of Coal-seam No. 1; Youngstown, Ohio.

Rhabdocarpus costatus (n. sp.).

Plate 44, Fig. 8.

Nut large, $1\frac{5}{8}$ inches long by $1\frac{1}{4}$ wide; outline round-ovate or elliptical, rounded below, abruptly acuminate at summit; surface marked by numerous longitudinal carinæ, of which alternate ones are strong and acute; intermediate ones lower and rounded. These carinæ rise at the summit and become obsolete some distance above the base.

Formation and locality: Shale over Coal No. 1; Youngstown, Ohio.

Genus NERIOPTERIS (n. gen.).

Frond pinnate or bi-pinnate; rachis strong, punctate; pinnules lanceolate, simple, entire; medial nerve strong, extending from base to summit; secondary nerves given off at an acute angle, numerous, simple or forked at base, parallel, equal; fructification marginal (?)

The plant to which the above name is given is, perhaps, not generically distinct from that upon which Brongniart founded his genus *Cannophyllites*, though departing widely from his description. The typical species of *Cannophyllites* is nowhere fully described, being simply enumer-

ated in the *Prodromus* of Brongniart and Unger's *Genera et Species*. From the generic description and a notice in the *Tableau des Genres*, p. 92, it seems that the type species (*C. Virlettii*, Br.) is a simple leaf, supposed, when the description was written, to belong to the *Zingiberaceæ*, and named *Cannophyllites*, from its supposed botanical affinities. Since that time other specimens have shown to Brongniart that his plant was a fern, and, without suggesting a substitute, he seems to have abandoned the name formerly given it (*Cannophyllites*), as liable to induce error.

Unger, in his *Genera et Species*, applies the name of *Cannophyllites* to a probably very different plant, from the Cretaceous formation.

Since our plant is distinctly a fern, with a compound frond and forked nervation, thereby excluded from Brongniart's genus *Cannophyllites*, as defined by him, it becomes necessary to give it a new generic title. I have, therefore, called it *Neriopteris*, in allusion to the strong resemblance borne by its pinnules to the leaves of *Nerium* (Gr. *Nerion*). This resemblance is due, not simply to their regular, lanceolate outline, but also to the strong, straight, rigid midrib which traverses them from base to summit.

By this latter character *Neriopteris* is widely separated from *Neuropteris*, some species of which have pinnules of not very dissimilar form.

The nervation of *Neriopteris* is most like that of *Tæniopteris*, among fossil ferns, but the species which should properly be included in that genus have mostly simple fronds, and always a rectangular nervation. The species from the Italian Tertiaries (*T. Bertrandi*, etc.), with pinnate fronds, and acute angled nervation, have almost nothing in common with these, and should plainly be separated from them.

In its general aspect our plant is also considerably like the larger species of *Alethopteris*, such as *A. macrophylla*, Newb., of which the upper pinnules are nearly as large, are entire, acute, and unequally cordate at the base. The texture of the leaf is, however, quite different, as is the nervation, and the lower pinnules of *Aleth. macrophylla* have scalloped edges. The margins of the pinnules in the specimens before me are all sensibly thickened and are apparently fructiferous. If this appearance is not fallacious, the fructification would be that of *Pteris*.

In form the pinnules of *Neriopteris* resemble those of the plant described and figured by Prof. Dawson (Acadian Geology, pp. 446, 484), under the name of *Phyllopteris antiqua;* but the nervation is entirely different.

In the enlarged figure of a portion of a pinnule, Plate 45, Fig. 3*a*, the nervation of *Neriopteris* is not quite accurately represented, as most of the nerves fork at the base, while, as there shown, they are all simple.

The marginal band shown in the figures, and noted in the description

of the pinnules of *Neriopteris*, is not visible in all my specimens, and I have had considerable doubt of its significance. It is possible that it is due simply to a thickened or revolute margin.

The nervation of the only species which I have of the genus is very fine and uniform, and must have been inconspicuous, and was apparently for the most part buried in the parenchyma of the pinnule when the plant was living. It often happens, therefore, that it is not clearly defined in the fossil state. When distinctly visible, however, it will be seen that, though fine and parallel, as in those of *Tæniopteris*, the secondary nerves are more or less forked; and generally, as in *Tæniopteris*, at or near the base.

Since the above description was written, Prof. Schimper has published his magnificent work, *Traite de Paleontologie Vegetale*, in which he proposes some important changes in the order *Tæniopteridæ*, restricting the genus *Tæniopteris* to the Coal Measures and the Permian formation, and taking as a type species *T. multinervis*, Weiss. (Pl. XXXVIII., Fig. 8). Prof. Schimper establishes a new genus, *Angiopteridium*, for the species of *Tæniopteris* which are found in the Triassic and more recent strata, and in which the fructification is bi-valvular and forms a sub-marginal band on the fronds or pinnules. In this genus he includes the old species of *Tæniopteris*, *T. Munsteri* and *T. Bertrandi*. *Tæniopteris vittata*, Brongt., forms the type of his new genus *Oleandridium*, which he supposes to have the fructification of *Asplenium*. It is evident, however, that our plant with lanceolate, cordate pinnules three inches in length, and with apparently a marginal fructification, has little in common with the simple, linear fronds, an inch and a half in width and a foot and a half in length of *Tæniopteris multinervis*. Prof. Goeppert has described two species of *Tæniopteris* from the Permian of Bohemia and Silesia, *T. coriacea* and *T. fallax* (*Foss. Flor. d. Perm. Form.*, p. 130, Tabs. VIII., IX), both of which he thinks may have pinnate fronds; but of this no proof is given, and the fronds or pinnæ described are very much larger than the pinnules of the plant before us. In his description of the genus *Tæniopteris*, Prof. Schimper describes the fronds as simple, and it is quite evident that all the well-known species he has grouped in this genus are so. Hence, as now constituted, the genus *Tæniopteris* cannot receive our plant, and we have, up to the present time, no facts which warrant us in so modifying *Tæniopteris* as to admit it. It is possible that future researches will bring to light species which will connect *Tæniopteris* and *Neriopteris;* but for the present, since the geological range of the genera is different—ours being limited to the base of the Coal Measures—and the frond, large and simple in one case, is pinnately divided in the other, we are compelled to regard them as generically distinct.

Neriopteris lanceolata (n. sp.).

Plate 45, Figs. 1 to 3*a*.

Frond pinnate or bi-pinnate; rachis strong, punctate; pinnules diverging from the rachis at an acute angle, lanceolate, acute, entire, narrowed and cordate or rounded at the base; medial nerve strong, straight, reaching to summit of pinnule; secondary nerves leaving the midrib at an acute angle, slightly curved at base, crowded, simple or forked near the base, parallel, equal.

As this is the only species yet known of this beautiful fern, and it has served as a basis for the generic description, but little more need be said to give a clear idea of it. I first obtained detached pinnules many years ago from the under-clay of Coal No. 1, at my father's mine, near Cuyahoga Falls, Summit County, and subsequently found a single one in the roof of the same seam at the mine of Dr. Amos Wright, in Tallmadge. Much the best specimens of the plant, however, I collected from the shale over the same coal at Youngstown, Ohio. Two of the specimens obtained from the latter locality are represented in Figs. 1 and 2, Plate 45. These show that the frond was pinnate, with a very strong rachis, which is punctate or scabrous, and was perhaps in life somewhat chaffy. In these specimens the pinnules are less distinctly cordate at base than in those from Tallmadge. In all the specimens except that obtained from Wright's mine, the margins of the pinnules are thickened as though by a band of fructification; but none of the specimens which I have seen are sufficiently perfect to justify me in asserting that this is a true explanation of this otherwise somewhat incomprehensible character.

I repeat here a remark made in the generic description that the figure given of the nervation of *Neriopteris*, Plate 45, Fig. 3*a*, is faulty inasmuch as it represents the secondary nerves of the pinnules as all simple, whereas the larger number of them are forked at the base, and they are generally somewhat curved at their junction with the midrib.

Formation and locality: So far as yet known, this fern has been found only at the base of the Coal Measures, and at the localities I have mentioned.

Odontopteris neuropteroides (n. sp.).

Plate 47, Figs. 1 to 3.

Frond bi-pinnate; pinnæ of lower part of frond linear in outline, composed of 20 or more pinnules, of which the terminal one is large and

irregular, as in *Neuropteris;* the upper pinnæ shorter and broader, with the terminal pinnule relatively smaller; pinnules of various forms; those near base of lower pinnæ ovoid and cordate, precisely like those of *Neuropteris;* upper ones more or less cuneate, strongly decurrent; the upper side of the base free as in *Otopteris;* pinnules of the upper pinnæ linear, often acute, connate and decurrent at base.

The terminal pinnæ of the frond are nearly entire, forming large, simple pinnules; nerves very numerous and fine, radiating from the center and decurrent portion of the bases of the pinnules.

This polymorphous species seems to unite *Odontopteris* and *Neuropteris.* The lower pinnules of the lower pinnæ being attached only by the center of the base, the nerves radiating from that, are not distinguishable from those of *Neuropteris;* while the upper portions of pinnæ and frond are clearly *Odontopteris.*

In the figures given on Plate 47, figure 1 represents a subdivision of a large frond of which several pinnæ are shown. On these the pinnules vary considerably in form, those at the base of each pinna having the form and nervation of the pinnules of *Neuropteris,* while the upper pinnules are those of *Odontopteris.* Fig. 2 shows the latter form still better. Fig. 3 exhibits one of the many aberrant forms which this protean species presents. The terminal pinnæ of the frond have been drawn, and will be engraved for another volume. They are very broad and simple, and would never be suspected of belonging to this plant if not found in connection with such pinnæ as are now figured.

Formation and locality: Fragments of the fronds of this plant have been found in the roof shale of several mines opened in Coal No. 1, in Mahoning and Summit Counties. All the good specimens, however, have come from the locality on Mill Creek, near Youngstown, which has furnished so many additions to the flora of the lowest coal-seam in our Coal Measures.

Odontopteris gracillima (n. sp.).

Plate 46, Figs. 1 to 3*a*.

Sterile frond bi-pinnate, pinnæ very numerous, extremely elongated and narrow, parallel among themselves, slightly arched upward; pinnules very short, rhomboidal, acute, those on the upper pinnæ and near the extremities of the lower pinnæ united by their margins, their summits forming a coarse serration of the margin of the pinnæ; venation relatively strong, the secondary veins of each pinnule usually consisting of two branches springing from the rachis of the pinna, of which the

lower is strongest and gives off three branchlets on the lower side; the upper vein is simple or once forked; both veins are sigmoidally curved. Sometimes both veins seem to spring from a common root, and the pinnule is then nourished by a single irregularly-pinnate vein. Fertile frond of the same general form as the sterile, except that the pinnæ are relatively narrower, and the inferior surface is completely covered with sori.

I have placed this peculiar form provisionally in the genus *Odontopteris*, though fully aware that it is very unlike any species hitherto described. It should perhaps form a new genus, but the difficulties in the way of giving good generic definitions of fossil ferns are so great, that the genera created should be as few as possible, and only established on a large amount of material. We may safely affirm that the plant before us exhibits a closer resemblance to some species of *Odontopteris* than to any other fossil ferns now known, but its nervation departs widely from that of all described species of that genus. In those it is very fine, and a large number of veins spring from the adherent base of the pinnule. In the plant before us, on the contrary, there are but two branches to each pinnule, sometimes indeed but one, and these are coarse and strong. Where a single branching vein supplies the pinnule, the nervation is not very unlike that of *Diplazium*, except that the tertiary veins are not so regularly pinnate and arched.

The fructification is apparently somewhat different from that of *Odont. Schlotheimi*, the entire under surface of the fertile frond being covered with sori. The details of the fructification are, however, not well shown in the only fertile frond which I possess.

Formation and locality: Over Coal No. 1; Youngstown, Ohio.

Alethopteris macrophylla (n. sp.).

Plate 48, Figs. 3, 3*a*.

Frond pinnate or bi-pinnate; pinnules ? simple, leaf-like, lanceolate; margins sometimes undulated or scalloped, revolute; apex acute; base obliquely cordate; medial nerve straight and strong; lateral nerves given off at a right angle from the midrib, very numerous, fine, simple or once forked.

This species presents marked differences from any other hitherto described, being readily distinguished by its very large, simple or sinuate-margined, acute, oblique-based pinnules, of which the midrib is strongly depressed. The secondary nerves are set at right angles with this, or

rather they spring from the midrib at an acute angle, but are immediately and abruptly curved downward till they reach a position perpendicular to the midrib, whence their course is remarkably straight to the margin. The secondary nerves are usually forked at the base, and each branch divides somewhere near the middle of the interval between the middle nerve and the margin, though often one or both branches may be simple. The secondary nerves are very fine and numerous, and being straight, parallel, and at right angles to midrib and margin, they give their pinnules the aspect of a *Tæniopteris*, but closer examination will show them to be distinctly forked even when detached; also the oblique bases of the pinnules show them to be parts of a pinnate frond.

It is clearly an *Alethopteris*, and nearly related to *A. lonchitica*, Br., and perhaps still more closely to *A. Sternbergii*, Goepp., in which the margin is not always entire. The pinnules are, however, two or three times as large as in either of these species, and the nerves are differently forked. The crenulation of the margin of the lower pinnules, and the lower side of the medial pinnule, is very different from that of *A. Sternbergii*, and such as to recall the leaves of *Comptonia*.

But for its rectangular nervation I should be inclined to include it in *Neriopteris*, but the nervation of the type species of that genus (*N. lanceolata*, N.) is not only oblique, but in its fineness and regularity rivals that of *Tæniopteris magnifolia*.

Formation and locality: Sandstone over Coal No. 1; Youngstown, Ohio.

Alethopteris grandifolia (n. sp.).

Plate 48, Figs. 1, 1*a*, 2.

Frond tri-pinnate, very large, 6 to 8 feet long, 3 to 4 broad; stipe 2 to $2\frac{1}{2}$ inches broad, marked with fine longitudinal striæ; pinnæ alternate, nearly opposite, the lower ones linear-lanceolate in outline, with rounded terminations, those near the extremity of the frond narrower, with waved margins terminating in long acutish points. The summit of the frond is formed by pinnæ reduced to pinnules, at first with waved margins, at the very summit with entire borders; pinnules closely set, decurrent and connate, at base of lower pinnæ deeply pinnatifid; toward the middle of the pinnæ, and higher in the frond, lanceolate-elliptical and with waved margins; still higher, lanceolate-elliptical with entire borders, 3 to 4 times as long as broad. Toward the summit of the frond, the pinnules become much smaller and relatively shorter, presenting an

appearance so different as to be readily mistaken for another species; medial nerve strongly marked, secondary nerves distinct, twice or thrice-forked, numerous.

This splendid species resembles in some respects *A. Massillonis*, Lesqx., but is a much stronger plant, and the frond is much more *leafy*, the pinnules broader and more closely set, more narrowed at base, and less broadly connate; secondary nerves less strongly marked, and more compound than in that species. A strong pinna from the middle of the frond resembles *A. Serlii*, but fragments of any other portion of the frond are not likely to be confounded with it. The pinnules in *A. Serlii* are never crenulate or pinnatifid as in this species. *A. Serlii* also belongs at a much higher level—above Coal No. 4. This species is limited to Coal No. 1.

Alethopteris grandifolia is the most common species in the coal mines of Tallmadge, where during my boyhood I collected thousands of specimens representing all parts of its great frond, and the many varieties into which it runs. I have also found this species at Massillon, in the Mahoning Valley, and, indeed, wherever Coal No. 1 is worked.

On Plate 48, two phases of *A. grandifolia* are given—that with narrow pinnules, often with waved margins (Fig. 1), and that with broad and entire pinnules (Fig. 2). These might very well be taken for distinct species; but they blend in such a way that it is impossible to separate them. A common feature in this species, but one that will serve to distinguish it from others, is this: the basal pinnule on the lower side of the pinna is frequently larger than its fellows, and pinnately lobed.

Formation and locality: Over Coal No. 1; Tallmadge, Ohio.

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ERRATA.

Page 4,	line 25,		for fine	read five.
" 6,	" 2,		" ridge	" right.
" 9,	" 12,		" arm-piece	" arm-pieces.
" 17,	" 28,		" caponifornis	" caponiformis.
" 26,	" 23,		" fine	" free.
" 32,	" 19,		after fig.	" 2.
" 57,	" 20,		for vans	" rays.
" 59,	" 20,		" oval	" oral.
" 60,	" 18,		" granulosa	" granulosus.
" 64,	lines 19, 20,		" Petraster	" Palæaster.
" 67,	" 31, 33,		" Urastrella	" Urasterella.
" 68,	line 12,		" oval	" oral.
" 75,	" 22,		" Brown	" Bronn.
" 90,	" 36,		" striæ	" stria.
" 125,	" 7,		" Leptocostia	" Leptocœlia.
" 131,	" 28,		" Whiles	" Whales.
" 170,	" 24,		" below	" above.
" 174,	" 20,		" anterior	" posterior.
" 183,	" 4	from bottom,	" characters	" chambers.
" 187,	" 7,		" diameter	" diameters.
" 189,	" 10,		add insignis.	
	" 2	from bottom,	for larger	" longer.
" 204,	" 7	" "	add cut A of C. Ohioense.	
	" 6	" "	" cut B of C. Ohioense.	
" 212,	" 20,		for spine	" spire.
" 216,	" 19,		" Trochydornia	" Trachydornia.
" 218,	" 13,		" Isonema	" Loxonema.
	" 20,		" 4	" 5.
" 230,	" 4	from bottom,	" under	" inner.
" 237,	last line,		" Hall	" Meek.
" 238,	line 25,		" Ophinroidea	" Ophiuroidea.
" 252,	" 5	from bottom,	" Squalli	" Squali.
" 257,	" 20,		" icthyolites	" ichthyolites.
" 267,	" 33,		" rapheidolobis	" rapheidolabis.

ERRATA.

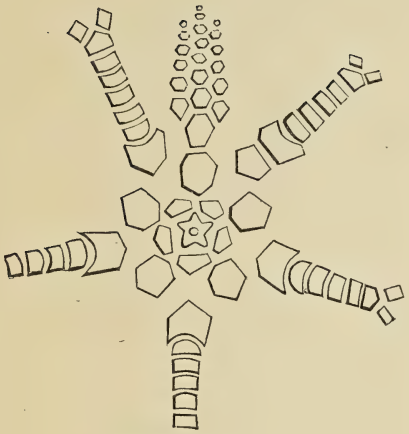
Page 271,	lines 1, 8 from bottom,	for noblissimus	read nobilissimus.
" 272,	" 8, 15, 18, 19 from bottom,	" "	" "
" 277,	line 17,	" Lepidostidæ	" Lepidosteidæ.
" 291,	" 29,	" Palcontologie	" Paleontologie.
" 320,	" 17,	" Dodoxylon	" Dadoxylon.

EXPLANATIONS OF PLATES.

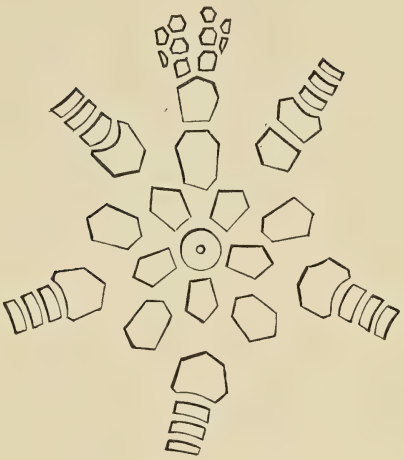
Plate III.,	line 5,	for Mr. Dyer's	read Dr. Hill's.
" III. bis,	line 11 from bottom,	" thin	" their.
" XI.,	line 17,	omit muscular.	
" XIX.,	" 4,	for top	" lip.
" XX.,	" 10,	" Newberryi	" propinquus.
	" 13,	" propinquus.	" Newberryi.

Note.—The sudden and severe illness of Mr. Meek prevented him from supervising the printing of his report, and occasioned the omission of the wood-cuts of the accompanying diagrams from the places they were intended to occupy in the text. The references given with them to the pages on which the species they represent are described, it is hoped will enable those who are interested in the study of this group of fossils to make some intelligent use of them, notwithstanding their removal from their proper places. It is but just, also, to say, that the typographical errors in Mr. Meek's report would have been eliminated if the proofs could have been submitted to him for correction. Under the circumstances, I am sure they will be pardoned, and that palæontologists will regret, not so much the trifling inaccuracies of Mr. Meek's text, as the sad cause which has produced them. J. S. N.

DIAGRAMS OF CRINOIDS.

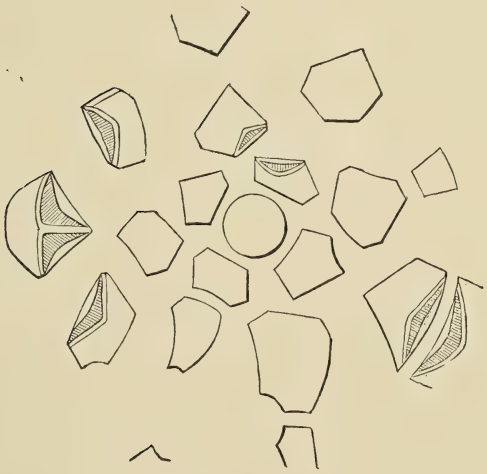


DENDROCRINUS CASEI.
p. 28.



POTERIOCRINUS CADUCEUS.
p. 26

HETEROCRINUS SIMPLEX.
p. 7.



LEPOCRINITES MOOREI.
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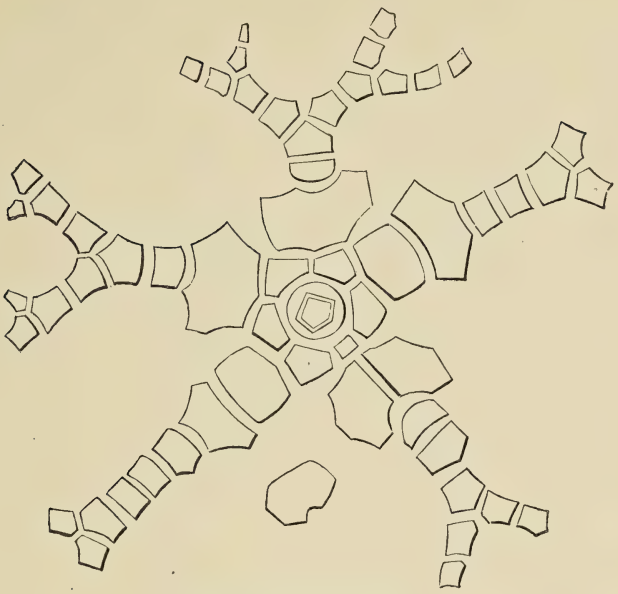
DIAGRAMS OF CRINOIDS.



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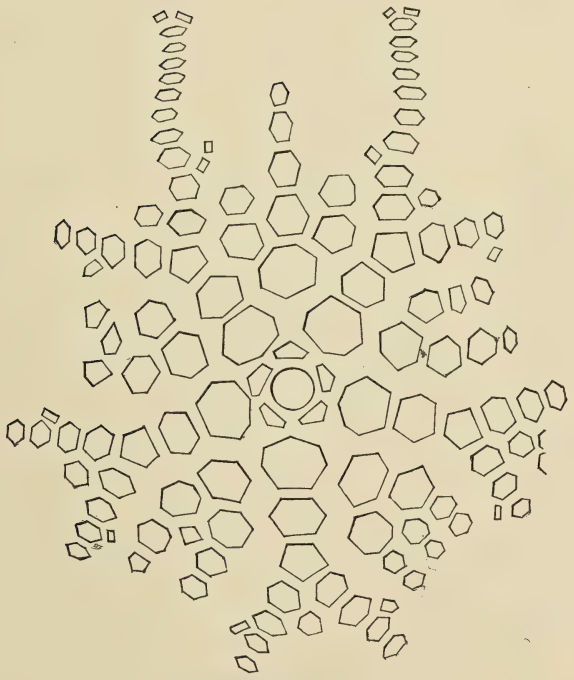
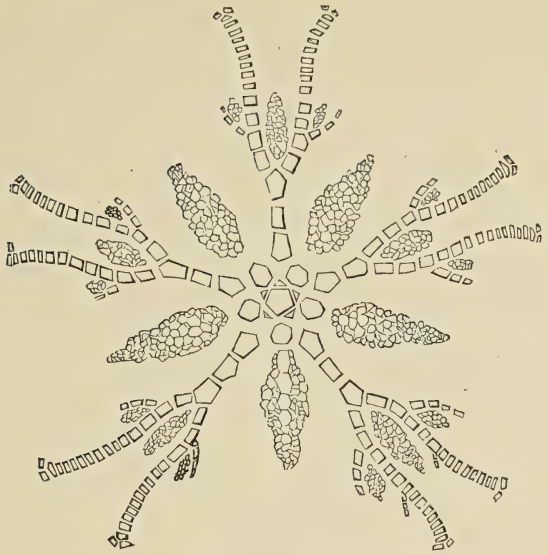
p. 17.

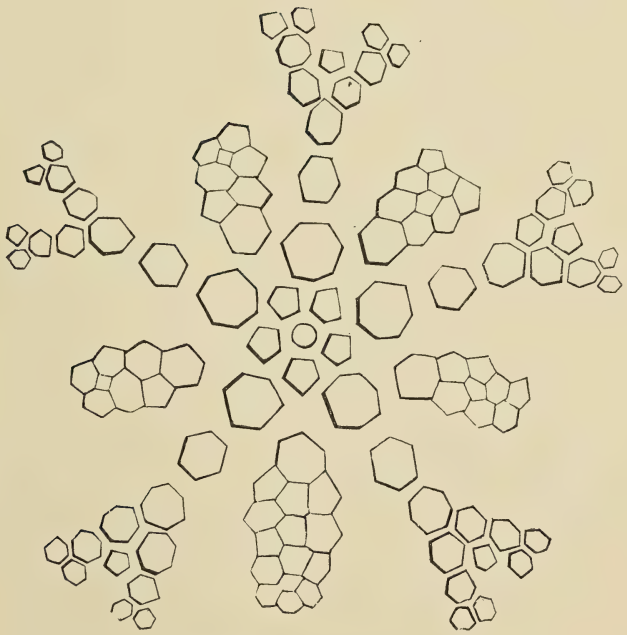


GLYPTOCRINUS DYERI.
p. 32.

DIAGRAMS OF CRINOIDS.



GLYPTOCRINUS NEALLI.
p. 34.



GLYPTOCRINUS DECADACTYLUS.
p. 30.

PLATE I.

PAGE.

Fig. 1. HETEROCRINUS HETERODACTYLUS?..... 12

1 *a*. Posterior view of body, arms, and a considerable portion of the column. Natural size. Dr. C. A. Miller's collection.
1 *b*. Same view of same enlarged, but with only a part of the column drawn.

Fig. 2. HETEROCRINUS HETERODACTYLUS? (variety)..... 14

2 *a*. Another specimen, apparently a variety of the same as fig. 1, showing posterior side of body, arms, and part of the column. Mr. Dyer's collection.
2 *b*. Same, magnified.

Fig. 3. HETEROCRINUS JUVENIS..... 10

3 *a*. A side view of body, arms, and a part of the column, natural size. Mr. Bean's collection.
3 *b*. A posterior view of a specimen consisting mainly of the body and a piece of the column; also showing first anal piece at (*a*), magnified a little more than 2 diameters. Mr. O'Neall's collection
3 *c*. One of the discs of the column, magnified about 2½ diameters, and showing the little cavities for the reception of the five minute, intercalated sub-basal pieces.

Fig. 4. HETEROCRINUS SIMPLEX..... 7

4 *a*. An oblique posterior view of a specimen consisting of the body and arms, and showing anal plate at (*a*). Nat. size.
4 *b*. Another view of same specimen.

Fig. 5. HETEROCRINUS SIMPLEX..... 9

5 *a*. Side view of body, arms, and a portion of the column of an individual that seems to have had the upper part of its arms broken away during the life of the animal, and subsequently restored. Mr. Dyer's collection. Nat. size
5 *b*. Same magnified.

Fig. 6. HETEROCRINUS SIMPLEX, *var*..... 9

6 *a*. Side view of body and arms, with a portion of column. Nat. size.
6 *b*. Posterior view of same, showing anal pieces at (*a*.)

Fig. 7. HETEROCRINUS SIMPLEX, *var*. GRANDIS..... 9

7 *a*. Side view of body, arms, pinnulæ, and a portion of the column. Nat size.
7 *b*. A side view of a part of one of the arms magnified.
7 *c*. Dorsal view of same.

Fig. 8. HETEROCRINUS LAXUS..... 14

8 *a*. Posterior view of body and arms; showing also the anal plates at (*a*). Nat. size. Type specimen from Mr. Dyer's collection.
b. Anterior view of same.

Fig. 9. HETEROCRINUS SUBCRASSUS..... 15

9 *a*. Side view of body and arms, with a piece of the column. Nat. size. Mr. O'Neall's collection.
9 *b*. Posterior view of same, showing anal series of pieces at (*a*).

Fig. 10. HETEROCRINUS CONSTRICTUS..... 3

10 *a*. Side view of body and portions of the arms. Nat. size. Type specimen from Mr. Dyer's collection.
10 *b*. Posterior view of same, showing anal piece.

Fig. 11. HETEROCRINUS CONSTRICTUS, *var*. COMPACTUS..... 4

A side view of body, arms, and a part of the column. Mr. Dyer's collection.

Fig. 12. HETEROCRINUS EXILIS, *var*. EXIGUUS..... 5

Posterior view of body, arms and a part of column; also showing anal plates at (*a*). Mr. Dyer's collection.

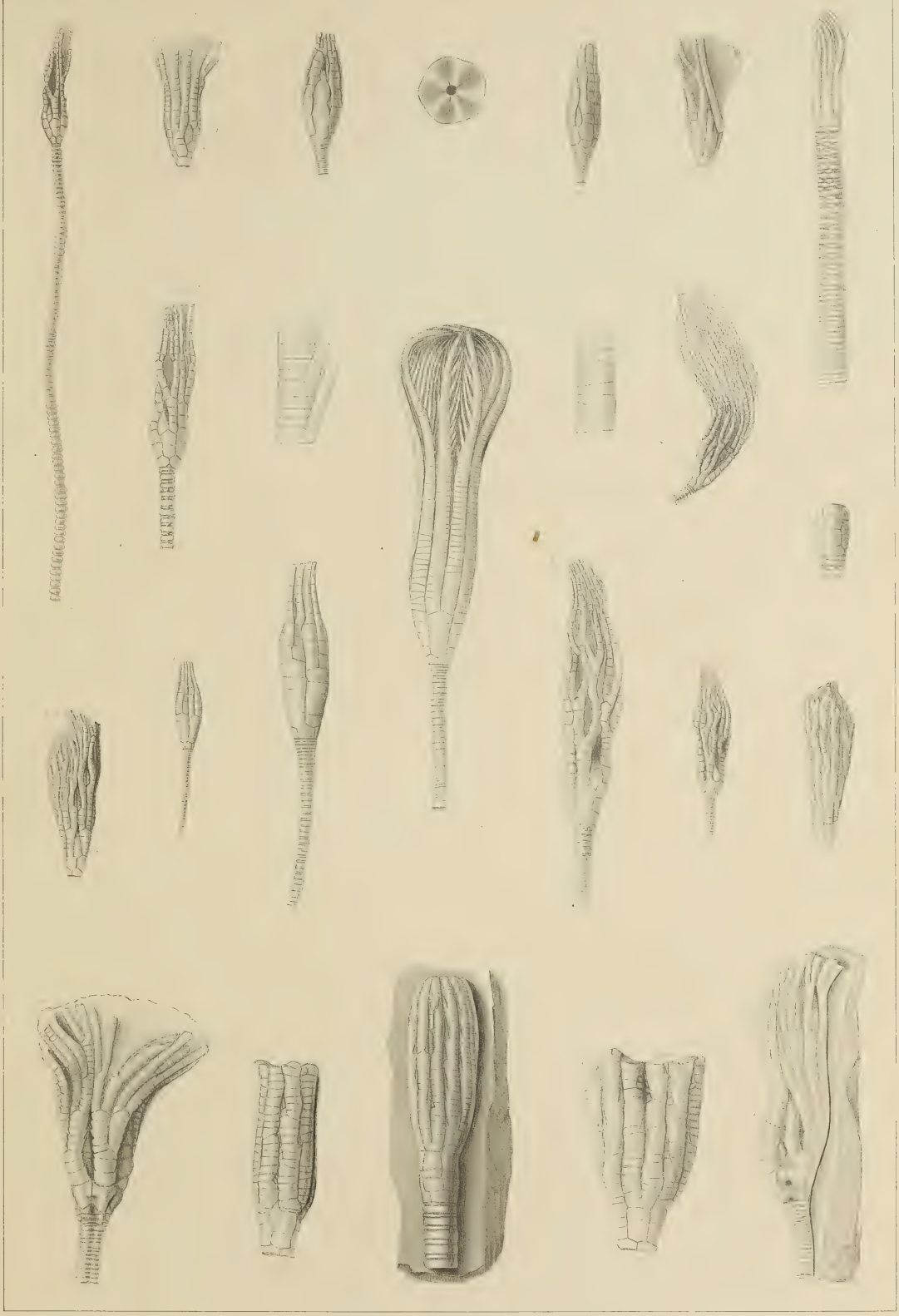


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PLATE II.

PAGE.

Fig. 1. GLYPTOCRINUS BAERI 37

1 *a*. A side view of the body and arms, with their pinnulæ; all somewhat flattened by pressure.

1 *b*. Another specimen, consisting of the arms and pinnulæ only, as seen spread out in the matrix. Both originals in Dr. Baer's collection.

Fig. 2. GLYPTOCRINUS DYERI 32

2 *a*. A posterior view of a specimen consisting of the body and portions of the arms. Mr. Dyer's collection.

2 *b*. A side view of another specimen, consisting of body, arms and pinnulæ. Mr. Dyer's collection.

2 *c*. A posterior view of body and lower part of arms. *G. Dyeri, var. sub-globosus.*

Fig. 3. GLYPTOCRINUS O'NEALLI 34

3 *a*. Side view of body, arms, pinnulæ, and a portion of the column. Mr. O'Neall's collection.

3 *b*. Posterior view of another specimen, showing body and arms, anal series of plates, etc. Mr. O'Neall's collection.

3 *c*. Same view of another specimen, with the arms broken away so as to expose the vault, composed of minute pieces; also the very small anal opening at (*o*). Mr. O'Neall's collection.

Fig. 4. GLYPTOCRINUS PARVUS ..... 36.....

4 *d*. Side view of body, arms, pinnulæ, and a few segments of columns. [The body is somewhat crushed in the specimen, and the arrangement of the pieces may not therefore be in all respects exactly represented.] Mr. Dyer's collection.

4 *b*. A similar view of another specimen in Mr. Dyer's collection.

Fig. 5. GLYPTOCRINUS DECADACTYLUS 30

5 *a*. A side view of body and the lower parts of the arms of an unusually large, fine specimen, belonging to Mr. Dyer's collection *

5 *b*. A posterior view of another similar but smaller specimen in Mr. Dyer's collection.

Fig. 6. ANOMALOCRINUS INCURVUS 17

6 *a*. A posterior view of body, parts of the arms, and a few joints of the column, showing the anal piece (*a*), and an abnormal sixth basal piece (*b*). Mr. Miller's collection.

6 *b*. Anterior view of same.

6 *c*. An end view of the column, near the body, magnified about 2½ diameters, to show that it is composed of an aggregation of numerous minute calcareous particles. The large central cavity is filled with crystalline calcareous matter, and may be larger than natural, in consequence of the solution of the surrounding part, or other accidental removal of the same.

6 *d*. The root, or expanded part of the base of the column, as it grew attached to a mass of rock, composed of comminuted shells, etc. [This specimen is not positively known to belong to this species, but from its peculiar structure, it is believed to be the root of the same.] Mr. Dyer's collection.

6 *e*. A part of the column of the above, from just above the root, magnified about 2½ diameters, to show its complex structure as seen in a side view.

6 *f*. An end view of the column, at 0.43 inch above the root, 6 *d*.

---

* This fine specimen, by some unknown agency, disappeared from the collections borrowed from C. B. Dyer, Esq., of Cincinnati. A liberal reward will be paid for its delivery to that gentleman, or for any information by which it can be recovered. It can be readily identified by the figure here given, wherever it may be.

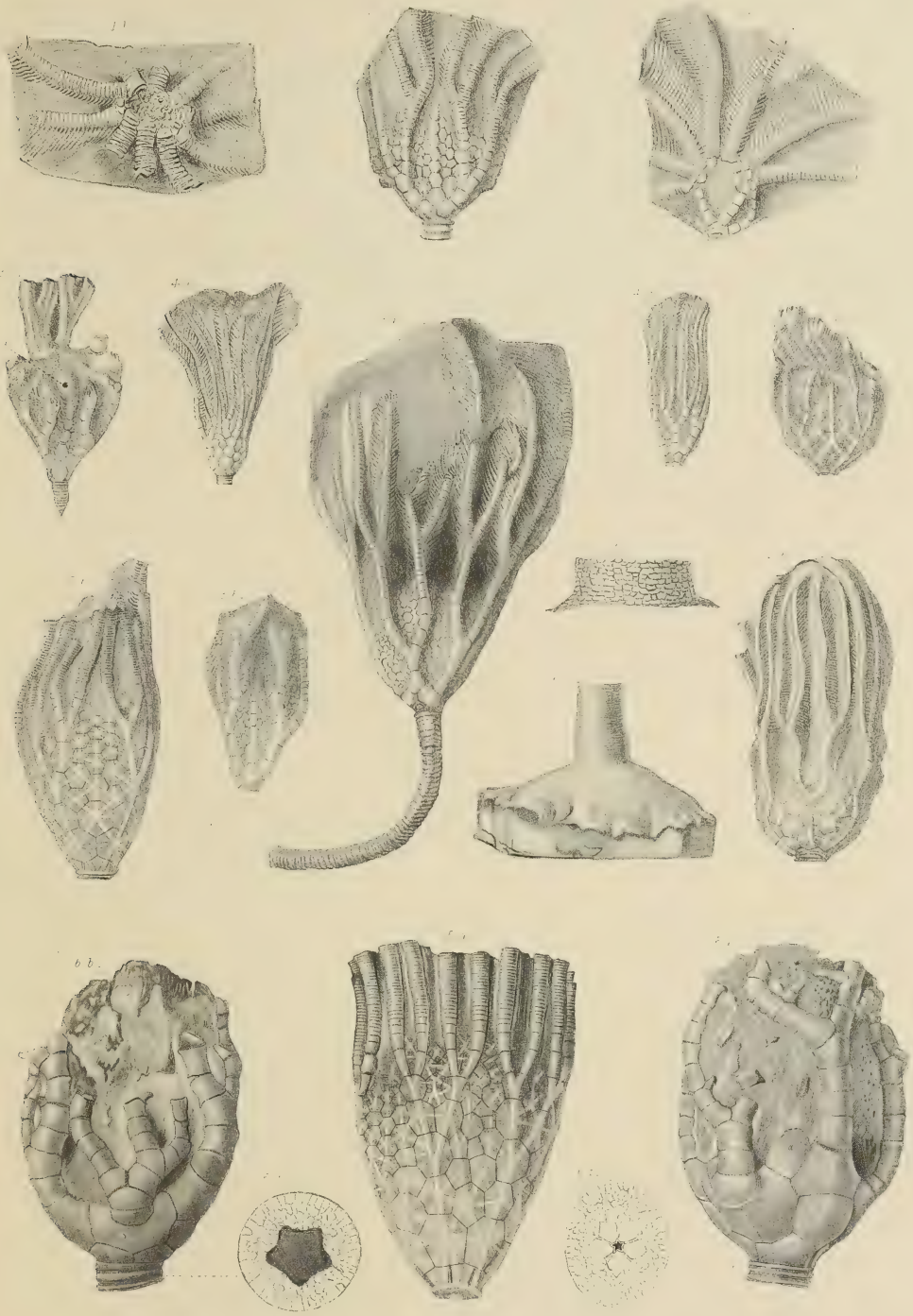

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PLATE III.

PAGE.

Fig. 1. LICHENOCRINUS CRATERIFORMIS 51

1 *a*. Upper side of disc, with the long appendage removed. Mag. 3 diameters. Mr. Dyer's collection.

1 *b*. A smaller individual growing on the middle of the glabella of a trilobite, and having a part of the plates and appendage of the upper side removed, so as to expose some of the internal radiating lamellæ. Mag. 2 diameters. Mr. Dyer's collection.

1 *c*. Upper side of a large specimen, showing disc plates and the broken end of the long central appendage. Mag. 2 diameters. Mr. Dyer's collection.

1 *d*. The flat under side of same specimen, as seen separated from the body upon which it grew, in such a manner as to leave the thin basal layer attached to the station, and thus expose numerous radiating striæ, and a small central opening (the latter apparently due to some accident). Mag. 2 diameters. Mr. Dyer's collection.

1 *e*. A side view of same specimen. Mag. 2 diameters. Mr. Dyer's collection.

1 *f*. A basal layer or platform attached to its original station, and showing its upper or inner structure, as exposed by the removal of the disc plates and internal lamellæ. Natural size. Mr. Dyer's collection.

1 *g*. Same, magnified 2 diameters. Mr. Dyer's collection.

1 *h*. Another basal layer, exposing its inner surface in the same way, with a smaller central circumscribed space. Mag. 2 diameters. Mr. Dyer's collection.

1 *i*. The circumscribed central area, magnified 6 diameters, to show that the radiating lines corresponding to the lamellæ of the interior are arranged in cycles, like the septa of a coral; five at equal distances apart, reaching the center, with three slightly shorter ones between each two of the longest, and another still shorter series intercalated regularly between the others. Mr. Dyer's collection.

1 *j*. A specimen, with the under or attached side separated from the body on which it grew, so as to expose its under surface, which is quite smooth, but shows, when moistened and examined under a magnifier, traces of the inner rays through its translucent substance. It also has one edge (the upper one in the drawing) folded upon itself in such a manner as to expose some of the disc plates of the upper side; but as the plates are curved and not broken along the folded edge, nor the sutures gaping there, this folding of the edge could not have resulted from flexibility of the disc, but seems to be a deformity produced during the growth of the animal. Mag. 3 diameters. Mr. Dyer's collection.

1 *k*. A slab of rock with two of the small discs placed, one partly upon or against the other, and showing the long appendage of each tapering off to an extremely attenuated extremity. Natural size. Mr. Dyer's collection.

1 *l*. Another larger individual growing on the shell of an *Orthis testudinaria*, and showing nearly three inches of its column-like appendage broken at its free end. Nat. size. Mr. James's collection.

1 *m*. A portion of the lower sub-pentagonal part of the long appendage of same, magnified 3 diameters, to show the alternately interlocking arrangement of its pieces there.

1 *n*. An end view of same, showing section of internal canal.

1 *o*. A piece of same farther up, where the pieces become nearly opposite.

1 *p*. The body and a part of the base of the appendage of the same specimen enlarged three diameters, to show how exactly it conforms to the inequalities of the surface of the shell upon which it grew.

1 *q*. Two smaller individuals growing on the shell of an *Orthis testudinaria*. Mag. a little more than 2 diamet rs.

1 *r*. Two others, growing on same species of *Orthis*, one of them with the upper side of the disc weathered so as to expose the edges of the lamellæ within. Nat. size. Mr. Dyer's collection.

1 *s*. Two individuals with the plates of the upper side partly removed so as to show the lamellæ within. Nat. size. Mr. Dyer's collection.

1 *t*. The same magnified two diameters.

Fig. 2. LICHENOCRINUS DYERI 51

A specimen showing the upper side of the disc, with its numerous very small pieces, and the base of its appendage in the middle. Nat. size. Mr. Dyer's collection.

Fig. 3. 46

3 *a*. A fragment having the structure and appearance of the column-like appendage of *L. Dyeri*, and showing its smaller end tapering rather abruptly to a blunt point. Mr. Dyer's collection. Nat. size.

3 *b*. A portion of same, magnified 3½ diameters.

Fig. 4. LEPOCRINITES MOOREI 39

4 *a*. Side view of body and a part of column. Nat. size. Mr. Moore's collection.

4 *b*. Another view of same, showing the anal opening, etc.

Fig. 5. AGELACRINITES PILEUS? 56

5 *a*. View of upper side. Nat. size. Mr. Dyer's collection.

Fig. 6. AGELACRINITES CINCINNATIENSIS 55

6 *a*. View of upper side. Nat. size.

6 *b*. Same, enlarged 2 diameters. Mr. Dyer's collection.

Fig. 7. AGELACRINITES VORTICELLATA 57

7 *a*. View of upper side. Nat. size.

7 *b*. Same, enlarged 2 diameters. Mr. Dyer's collection.

Fig. 8. HEMICYSTITES STELLATUS 52

8 *a*. Upper surface. Nat. size.

8 b. Same, enlarged 2 diameters. Mr. Dyer's collection.

Fig. 9. HEMICYSTITES GRANULATUS 54

9 *a*. Side view. Nat. size.

9 *b*. Same, enlarged 2 diameters. Mr. Dyer's collection.

Geological Survey of Ohio.

LOWER SILURIAN. (Cincinnati group.) PLATE 3.

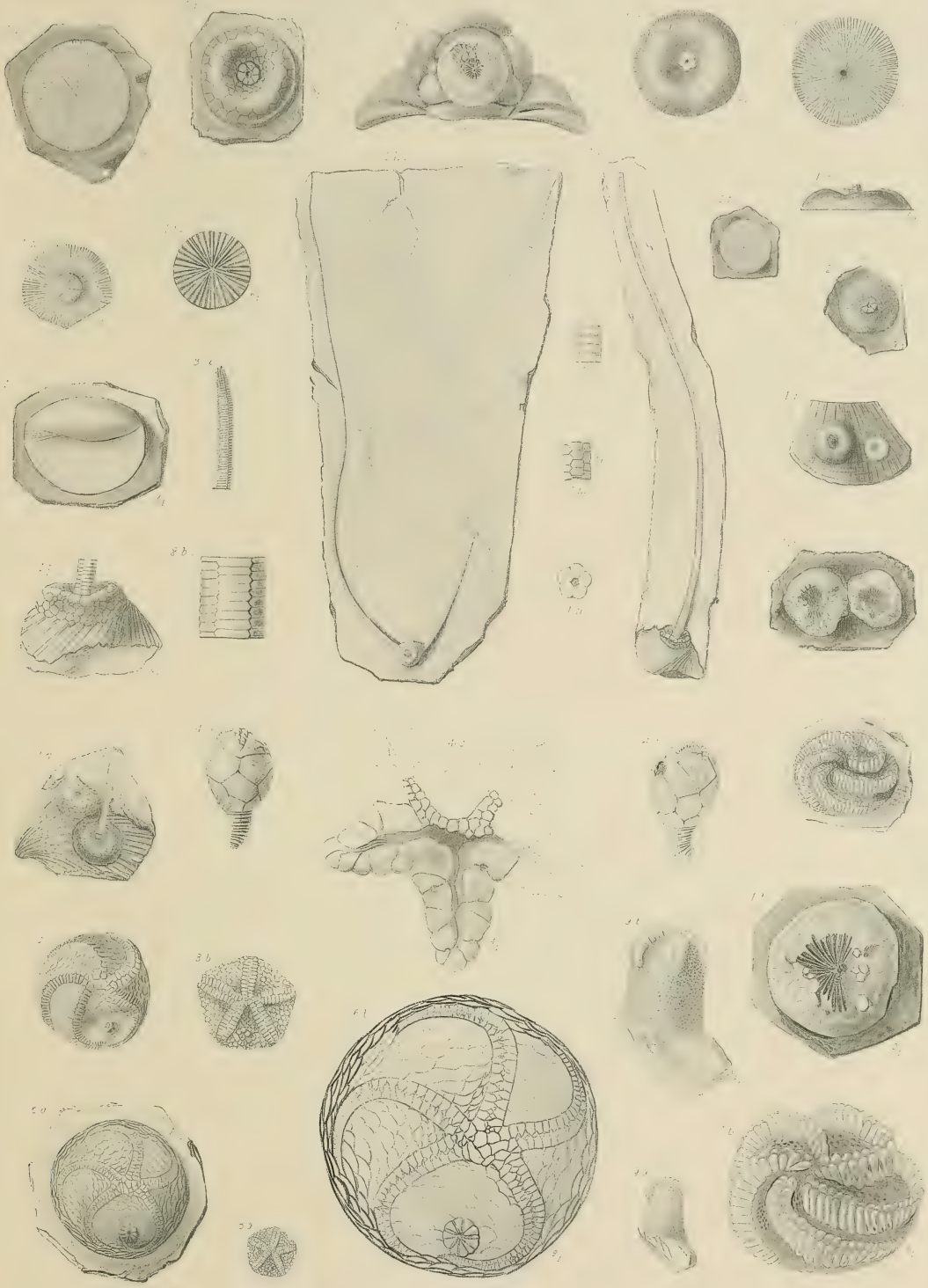

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PLATE III. *bis.*

PAGE.

Fig. 1. POTERIOCRINITES (DENDROCRINUS) CADUCEUS 26

1 *a*. A lateral view of body, a part of the column, and the arms, excepting their more slender subdivisions. Nat. size. Mr. O'Neall's collection.
1 *b*. A part of the column of same, magnified 2 diameters.
1 *c*. Portion of slender subdivisions of the arms, magnified about 4 diameters.
1 *d*. Posterior view of body and portions of the arms, with also a few segments of the column attached. Mr. O'Neall's collection.

Fig. 2. POTERIOCRINITES (DENDROCRINUS) CASEI 28

2 *a*. A specimen showing the anterior side of the body, with portions of some of the arms, and a piece of the column attached. The large ventral prolongation is also imperfectly seen, like arms above, composed of small pieces, marked with little ridges arranged zigzag. Mr. Case's collection.
2 *b*. An end view of the column of same, showing its distinctly pentagonal form.
2 *c*. A posterior view of a young individual, showing body, arms, and a short piece of the column. Mr. Dyer's collection.

Fig. 3. POTERIOCRINITES (DENDROCRINUS) DYERI..... 24

3 *a*. Lateral view of body, arms, and a portion of the column. Mr. Dyer's collection.
3 *b*. A similar view of a smaller specimen, with the body plates somewhat deranged by pressure. Mr. Dyer's collection.

Fig. 4. POTERIOCRINITES (DENDROCRINUS) POSTICUS..... 22

4 *a*. Posterior view of one of the type specimens, showing body, portions of some of the arms, and a part of the ventral prolongation. Mr. Dyer's collection.
4 *b*. Same view of another one of the type specimens, showing rather more of the arms. Mr. Dyer's collection.
4 *c*. An anterior view of same.

Fig. 5. POTERIOCRINITES (DENDROCRINUS) CINCINNATIENSIS..... 20

5 *a*. A posterior view of body, most of the arms, and a part of the column, of type specimen. Mr. Dyer's collection.
5 *b*. Same view of another smaller specimen, with arms removed.

Fig. 6. ANOMALOCYSTITES BALANOIDES 41

6 *a*. An anterior view of the lower part of the body only. Mr. Dyer's collection.
6 *b*. Side view of same.
6 *c*. A posterior view of same, showing the deeply sinuous character of the basal pieces, and some remains of the extremely thin segments of the very thick upper end of the column.

Fig. 7. STENASTER GRANDIS 66

7 *a*. Dorsal view of a specimen with two of the rays folded over upon the disc, so as to show thin ventral sides; one of the others curved and compressed laterally, and the other two with their extremities broken away. Mrs. Haines's collection.
7 *b*. A piece of one of the rays enlarged; under side view.
7 *c*. A piece of same, dorsal side, more highly magnified.

Fig. 8. PROTASTER GRANULIFERUS 68

8 *a*. A ventral view of a specimen consisting of a part of the disc and the inner ends of the rays, magnified about 2 diameters.
8 *b*. A small portion of the integument of the dorsal side of the disc, magnified to show its minutely granular structure.

Fig. 9. POTERIOCRINITES (DENDROCRINUS) POLYDACTYLUS..... 22

A posterior view of the body and arms, with a piece of the column attached.

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LOWER SILURIAN. (Cincinnati group.) PLATE 3 bis.

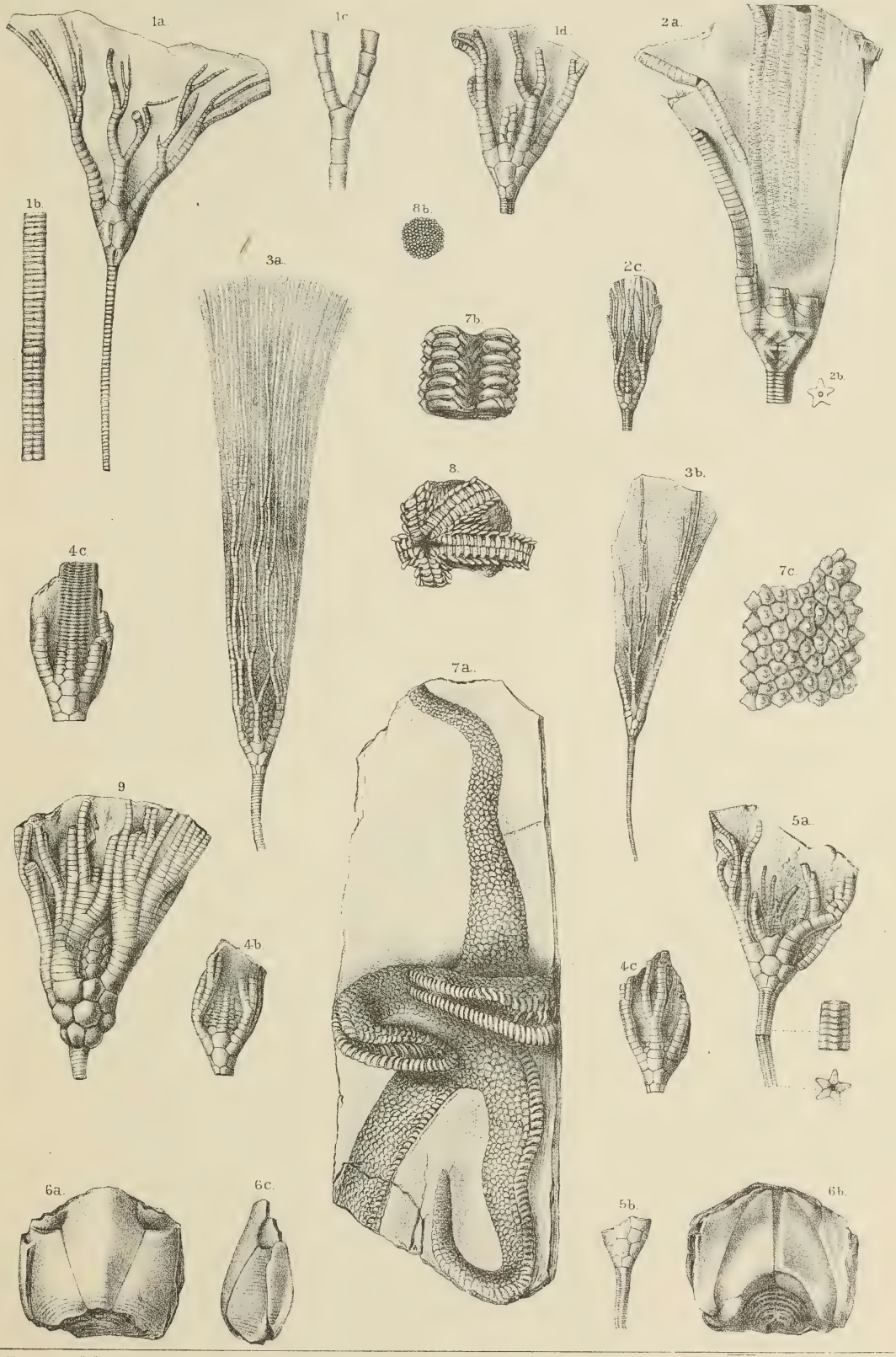

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PLATE IV.

PAGE.

Fig. 1. PALÆASTER SHAEFFERI 66

An outline view of the ventral side, from plate IX., fig. 2, of 20th Ann. Regents' Report, N. Y.

Fig. 2. PALÆASTER DYERI 58

2 *a*. A view of the ventral side of a specimen consisting of a part of the disc, and portions of the rays, showing some of the marginal and adambulacral pieces, with their spines, and at one place a few dorsal pieces of one of the rays brought into view by distortion; the whole being much obscured by adhering shaly matter. The ambulacral canals are doubtless made to appear narrower than natural, at the broken end of the lower ray, by accidental pressure. Mr. Dyer's collection.

2 *b*. A part of the under side of one of the rays, showing the marginal and adambulacral pieces with some of their spines, all magnified 2 diameters.

2 *c*. A part of the dorsal side of one of the rays, showing the angular forms, and loose arrangement of the dorsal pieces, as magnified nearly 2 diameters.

2 *d*. Two of the spines of the marginal and adambulacral pieces, magnified 3 diameters.

2 *e*. The madreporiform piece, magnified 2 diameters.

2 *f*. Two of the very small dorsal spines, magnified 3 diameters.

Fig. 3. PALÆASTER GRANULOSUS ?..... 60

3 *a*. Ventral side of a specimen showing two and a part of a third ray, and, less distinctly, a portion of the disc. The ranges of pieces outside of the marginal rows belong to the dorsal series, being here brought into view by accidental pressure. Mr. Dyer's collection.

3 *b*. A part of one of the rays, showing the marginal, adambulacral, and ambulacral pieces, all in their relative positions, and magnified about 2 diameters.

3 *c*. Dorsal side of a piece of one of the rays, near its middle, showing the arrangement and form of the dorsal pieces, as seen magnified about 2½ diameters.

Fig. 4. PALÆASTER JAMESII..... 62

View of the ventral side. This specimen has the appearance of having the marginal pieces removed, so as to expose the inner side of the dorsal pieces. This, however, may be owing to some peculiar character of the fossil, or due to some other accidental cause. The oral pieces are not clearly seen, and may not have exactly the characters represented. Mr. James's collection.

Fig. 5. PALÆASTER INCOMPTUS..... 64

5 *a*. Dorsal side of a compressed specimen, with the pieces somewhat displaced.

5 *b*. The madreporiform body of same, magnified about 5 diameters.

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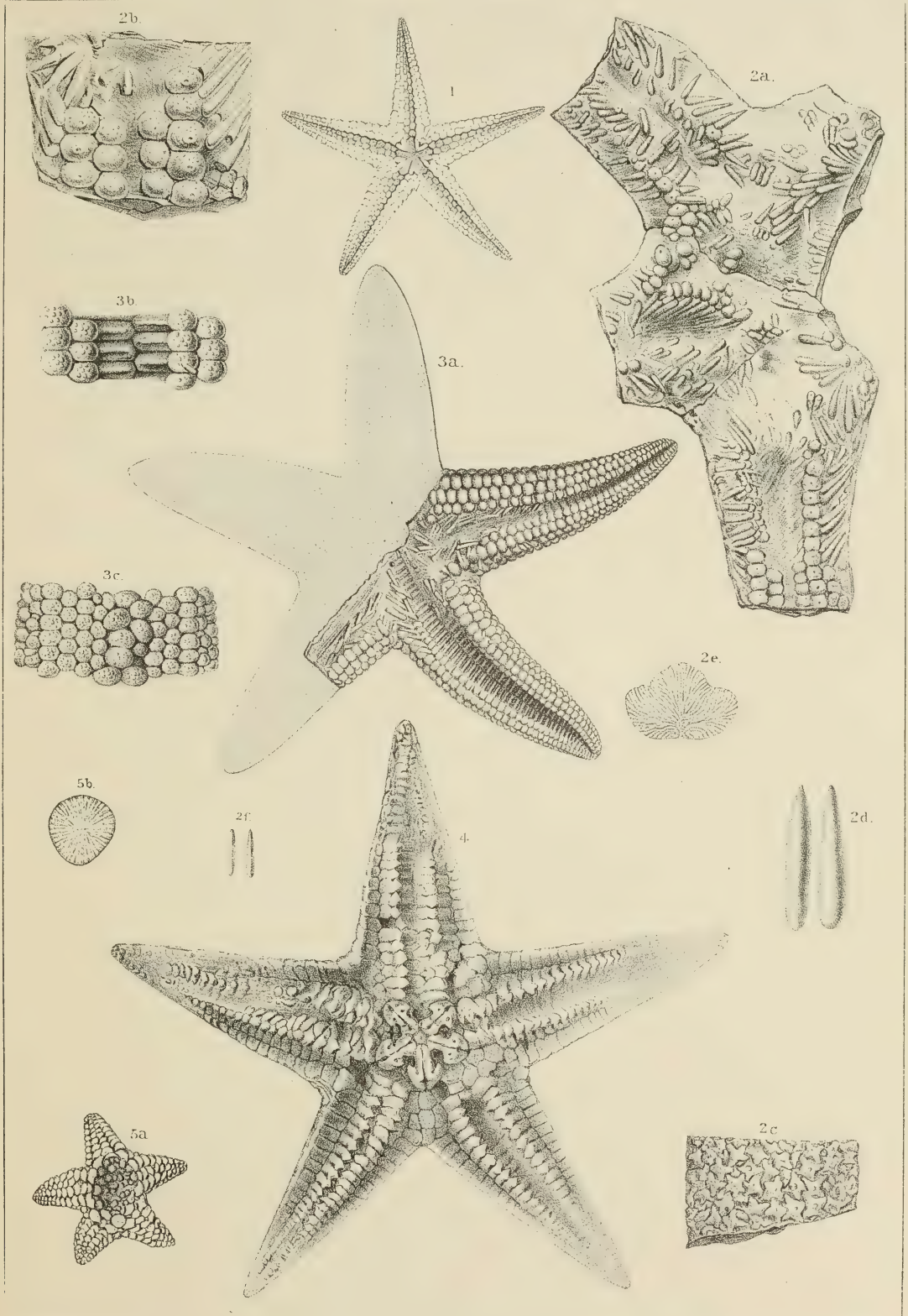
LOWER SILURIAN. (Cincinnati group.). PLATE 4.



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Th^s Sinclair & Son, lith. Phila.

PLATE V.

PAGE.

Fig. 1. PTILODICTYA SHAFFERI 69

1 *a*. Parts of the stems and branches. Natural size. Mr. Shaffer's collection.
1 *b*. Same magnified about 2½ diameters.
1 *c*. A part of one of the branches, magnified about 12 diameters, to show the oval form of the pores, and the striated interspaces.

Fig. 2. PHOLIDOPS CINCINNATIENSIS 130

2 *a*. A view from above, magnified about 3 diameters. Mr. James's collection.
2 *b*. Profile of same, magnified as above.
2 *c*. Cross lines showing the natural size of the specimen.

Fig. 3. LEPTÆNA SERICEA ? 70

3 *a*. Dorsal view, magnified 1½ diameters.
3 *b*. Interior of ventral valve, magnified 1½ diameters, showing muscular impressions, etc.
3 *c*. Interior of dorsal valve, magnified 1½ diameters, to show muscular impressions and cardinal and brachial processes.
3 *d*. Surface striæ, magnified.
3 *e*. Section of the two valves united.
3 *f*. A dorsal view of the variety *rugosa*, magnified as above, showing cardinal area, and the oblique wrinkles near the hinge line.
3 *g*. Interior of dorsal valve of same, showing cardinal and brachial processes, muscular impressions, etc., as magnified 1½ diameters.
3 *h*. Section of the united valves.

Fig. 4. STROPHOMENA SULCATA 85

4 *a*. A dorsal view of a rather small specimen.
4 *b*. A ventral view of a larger individual.
4 *c*. Cardinal view of same, showing area, pseudo-deltidium, perforation of beak, etc.
4 *d*. Anterior view of same, showing mesial sinus and fold.
4 *e*. Surface striæ, magnified.

Fig. 5. STROPHOMENA SINUATA 87

5 *a*. Dorsal view.
5 *b*. Ventral view.
5 *c*. Cardinal view, showing area, false deltidium, and the minute perforation of the beak.
5 *d*. An anterior view, showing the much fainter sinus and fold than are seen in the last, as represented by fig. 4 *d*.
5 *e*. Surface striæ, magnified.
5 *f*. An imperfect specimen, showing cardinal process, and socket ridges of the interior of the dorsal valve.
5 *g*. Another, showing hinge teeth, and the cavity for the reception of the muscles, dental ridges, etc., of ventral valve.

Fig. 6. STROPHOMENA RHOMBOIDALIS, VAR. TENUISTRIATA 75

6 *a*. Ventral view.
6 *b*. Dorsal view.
6 *c*. Interior of dorsal valve, showing the short cardinal process, muscular scars, etc.
6 *d*. Section of the two valves united.
6 *e*. Surface striæ, magnified.

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(Cincinnati group.)

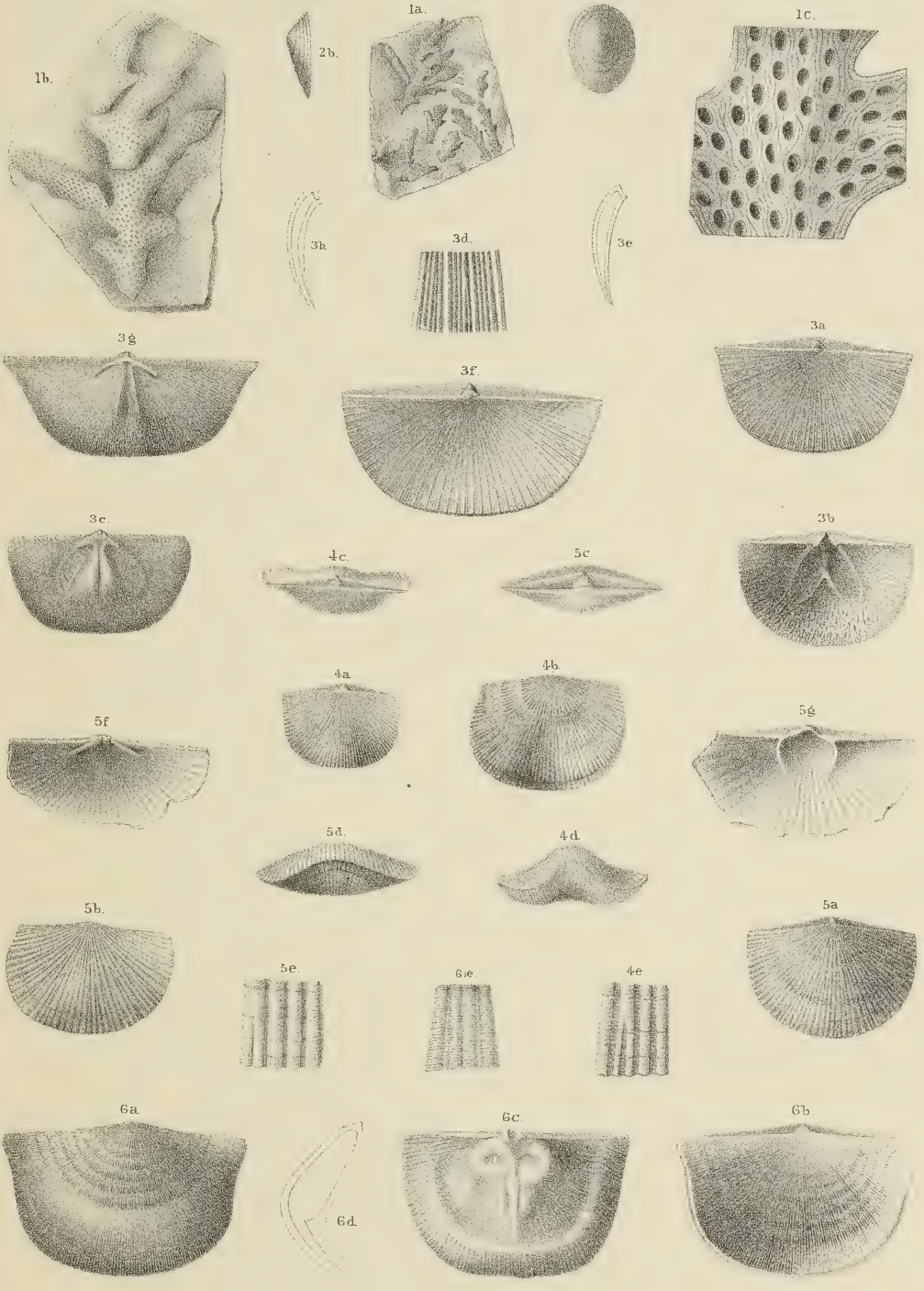

PLATE VI.

PAGE.

Fig. 1. STROPHOMENA NUTANS 77

1 *a*. View of dorsal side.
1 *b*. Ventral view.
1 *c*. Interior ventral valve, showing the cavity for the muscular attachments, hinge teeth, area, and pseudo-deltidium, as well as the thickened, wrinkled, and geniculated zone around the front and lateral margins.
1 *d*. Interior of dorsal valve, showing cardinal process, sockets, and obscure muscular markings.
1 *e*. Magnified surface markings.
1 *f*. Section of the two valves united.

Fig. 2. STROPHOMENA PLANO-CONVEXA 82

2 *a*. Ventral view.
2 *b*. Dorsal view.
2 *c*. Posterior view, showing area, pseudo-deltidium and minute perforation of beak.
2 *d*. Interior ventral valve, showing muscular cavity, hinge teeth, area, pseudo-deltidium, etc.
2 *e*. Section of the two valves united.
2 *f*. Interior of dorsal valve, showing the very small bipartite cardinal processes, oblique socket ridges, and obscure radiating ridges without well-defined muscular scars in the bottom of the valve.
2 *g*. Surface markings, magnified.

Fig. 3. STROPHOMENA PLANUMBONA 79

3 *a*. View of ventral side.
3 *b*. Dorsal view.
3 *c*. Interior of ventral valve, showing muscular cavity, hinge teeth, and thickened and wrinkled anterior and lateral margins.
3 *d* Interior of dorsal valve, showing the bifid cardinal process, muscular scars, etc.
3 *e*. Section of the two valves united.
3 *f*. Posterior view of the united valves, showing area, pseudo-deltidium, etc.
3 *g*. Surface striæ, magnified.

Fig. 4. STROPHOMENA PLICATA 81

4 *a*. Ventral view.
4 *b*. Dorsal view.
4 *c*. Posterior view, showing area, pseudo-deltidium, etc.
4 *d*. A lateral or profile view of same.
4 *e*. Interior of a dorsal valve, showing the short bifid cardinal process, sockets and oblique socket ridges, and obscurely some of the internal markings. Externally this specimen shows the characteristic oblique wrinkles.
4 *f*. Interior of ventral valve, with hinge teeth, muscular cavity, and cardinal area, with its pseudo-deltidium.
4 *g*. Section of the two valves united.
4 *h*. Surface markings, magnified.

Fig. 5. STROPHOMENA FILITEXTA 83

5 *a*. Ventral view.
5 *b*. A dorsal view of another specimen.
5 *c*. Interior of a ventral valve, showing the large, deep, very strongly defined muscular cavity, hinge teeth, etc.
5 *d*. Interior of a dorsal valve, showing the bifid cardinal process and socket ridges, with four strong ridges, and three linear ones between them, in the bottom of the valve, the whole of which is much roughened by little asperities.
5 *e*. Surface markings, magnified.

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LOWER SILURIAN. (Cincinnati group.) PLATE 6.

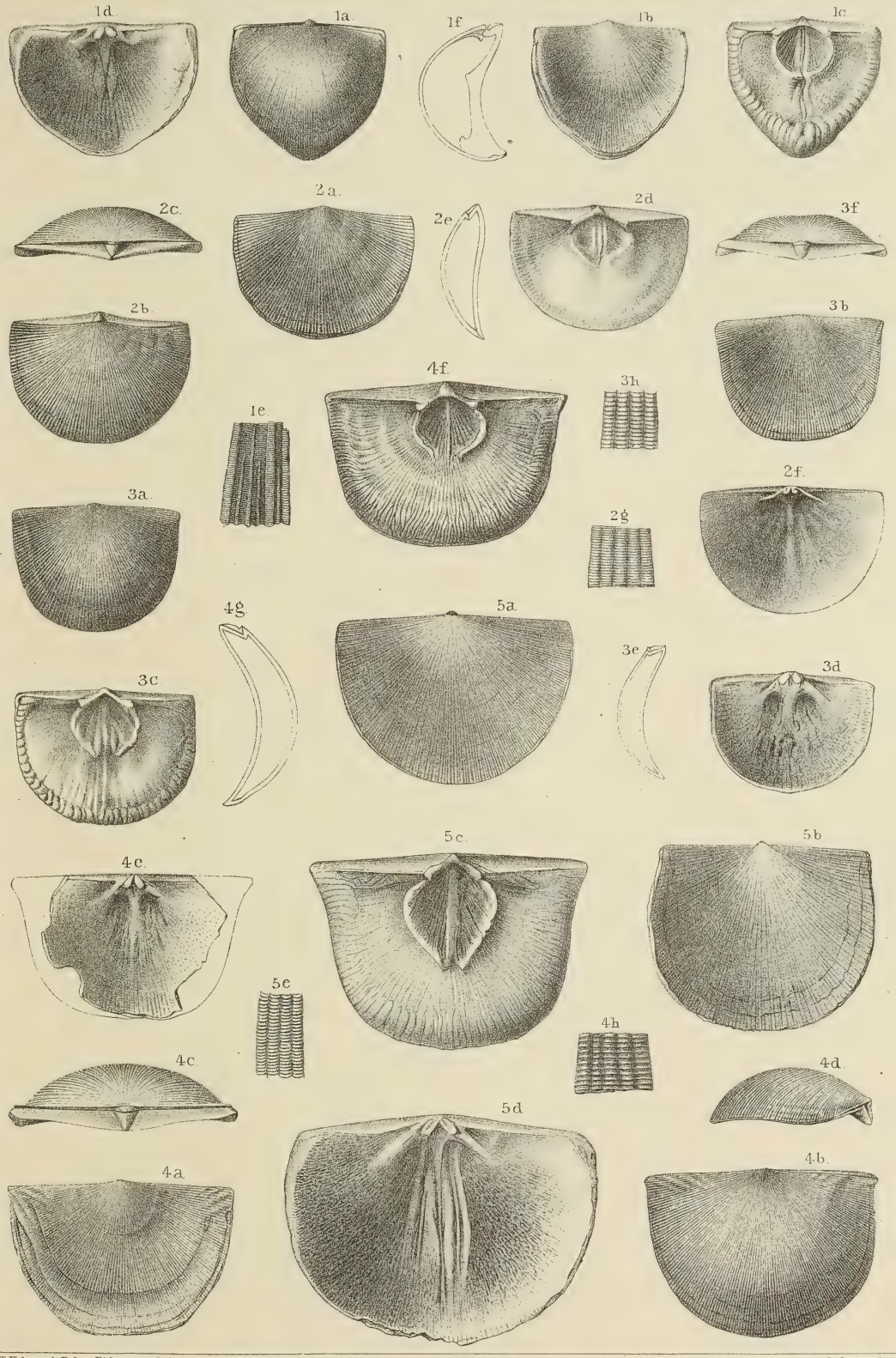

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PLATE VII.

PAGE.

Fig. 1. STROPHOMENA ALTERNATA 88

1 *a*. Ventral view of a rather long specimen.
1 *b*. Dorsal view of same, showing area, false deltidium.
1 *c*. Internal view of ventral valve, showing muscular impressions, hinge teeth, etc.
1 *d*. Interior of dorsal valve, showing muscular impressions, the bifid cardinal process, and a somewhat thickened and wrinkled ridge around near the anterior and lateral margins.
1 *e*. A section of the two valves.
1 *f*. Surface striæ magnified to show how several small ones usually occur between each two larger.
1 *g*. Some of the striæ much more magnified, to show the small, crowded lines of growth. The surface markings of the other varieties differ but little from this.

Fig. 2. STROPHOMENA ALTERNATA, *var.* NASUTA 90

2 *a*. A ventral view.
2 *b*. A section of same specimen, to show the strong deflection of the valves.
2 *c*. Ventral view of a smaller specimen, with the nasute character more strongly defined. Mr. Dyer's collection.

Fig. 3. STROPHOMENA ALTERNATA, *var.* FRACTA 91

3 *a*. A dorsal view of a large specimen.
3 *b*. Ventral view of another individual of more elongated form, showing a second growth around the anterior and anterior-lateral margins, often seen in this variety.
3 *c*. Interior view of same, showing hinge and muscular impressions.
3 *d*. Interior of ventral valve of a smaller specimen, showing the bifid cardinal process, and the muscular scars more remote from the same than in the other varieties.
3 *e*. Section of the two valves, showing their depressed form.

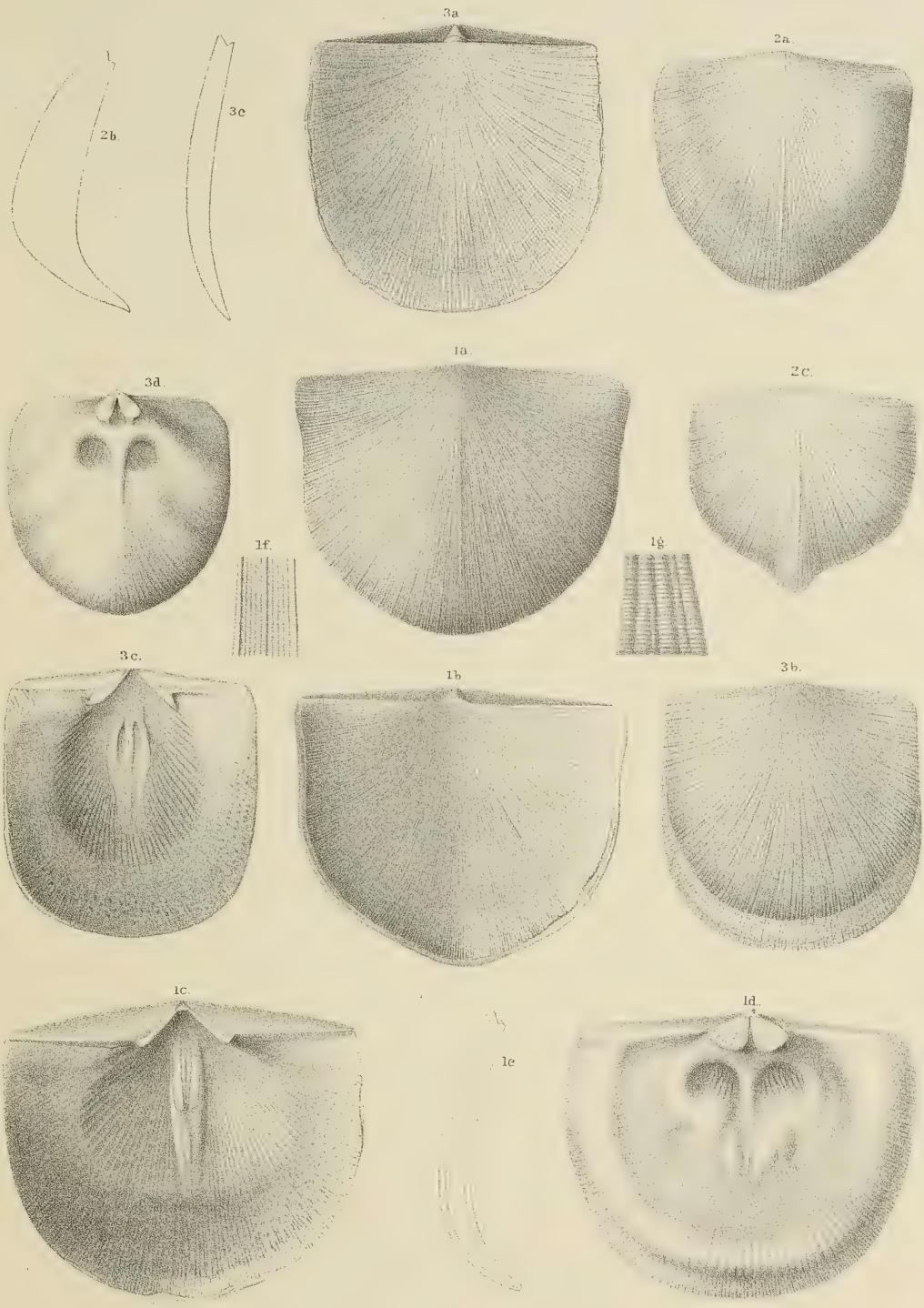
3a.
2a.
2b.
3c
1a.
3d.
2c.
1f.
1g.
3c.
1b
3b.
1c.
1e
1d.

PLATE VIII.

PAGE.

Fig. 1. ORTHIS EMACERATA 109

1 *a*. A dorsal view of a medium-sized specimen of the same form as one of the typical examples.
1 *b*. A profile view of same.
1 *c* A posterior view of same.
1 *d* A ventral view of a more transverse specimen, agreeing with the other typical example.

Fig. 2. ORTHIS EMACERATA 109

2 *a*. Dorsal view of a larger specimen, differing in form.
2 *b*. A ventral view of same.
2 *c* An internal view of ventral valve, showing muscular impressions, hinge teeth, etc.
2 *d*. Interior of dorsal valve showing muscular scars and cardinal and brachial processes.
2 *e* Profile of the specimen represented by fig. 2 *a*.
2 *f*. Cardinal or posterior view of same.
2 *g*. Surface striæ much magnified, to show the minute lines of growth as seen crossing the furrows between the striæ.

Fig. 3. ORTHIS EMACERATA *var.* MULTISECTA 112

3 *a*. Ventral view.
3 *b* A cardinal view of same.
3 *c* Interior of dorsal valve, showing muscular impressions, cardinal and brachial processes.
3 *d*. Surface striæ magnified, to show minute cross striæ in furrows

Fig. 4. ORTHIS BOREALIS 101

4 *a*. Dorsal view.
4 *b*. Profile of same
4 *c*. Anterior view of same.
4 *d*. Ventral view of a smaller specimen.
4 *e*. Dorsal view of same.
4 *f*. A cardinal or posterior view.

Fig. 5. ORTHIS BELLULA 103

5 *a* A dorsal view. Natural size.
5 *b*. Same, magnified 2 diameters.
5 *c*. Ventral view, magnified.
5 *d*. Cardinal or posterior view, magnified.
5 *e*. Anterior view, magnified.
5 *f*. Surface striæ, magnified.

Fig. 6. ORTHIS FISSICOSTA 106

6 *a*. Ventral view.
6 *b*. A dorsal view of same.
6 *c*. Cardinal view of same.
6 *d* Surface striæ and minute cross lines of growth, magnified.
6 *e*. Profile view of the specimen represented by fig. 6 *a*.
6 *f*. An internal view of a dorsal valve of a smaller specimen, showing hinge, with cardinal and brachial processes, without any visible muscular scars.
6 *g* An internal view of a ventral valve of a specimen with the cardinal margin broken away, showing an obscurely defined muscular cavity.
6 *h*. Interior of a ventral valve, showing small hinge teeth and an obscurely defined muscular cavity.

Fig. 7. ORTHIS PLICATELLA 108

7 *a*. Ventral view.
7 *b*. Dorsal view of same.
7 *c*. Interior of a dorsal valve, showing cardinal and brachial processes, without any muscular scars.
7 *d*. A profile view.
7 *e*. An anterior view.
7 *f*. A cardinal view.
7 *g*. Surface markings enlarged to show transverse striæ between the ribs, and minute traces of longitudinal striæ upon and between the same.
7 *h*. A ventral view of a specimen nearly intermediate between typical form of this species and the following variety.
7 *i*. A dorsal view of same.
7 *j*. Interior of dorsal valve of same, showing cardinal and brachial processes.

Fig. 8. ORTHIS PLICATELLA, *var.* TRIPLICATELLA 109

8 *a*. A dorsal view.
8 *b*. A ventral view.
8 *c*. Cardinal view, to show the very low area, as compared with figs. 7 *f* and 6 *c*.
8 *d*. Profile of same.
8 *e*. Surface markings, magnified.

Fig. 9. ORTHIS? ELLA 105

9 *a*. A dorsal view.
9 *b*. Profile.
9 *c*. Cardinal view, showing the very restricted character of the area.
9 *d*. Anterior view of same.

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LOWER SILURIAN. (Cincinnati group.) PLATE 8.

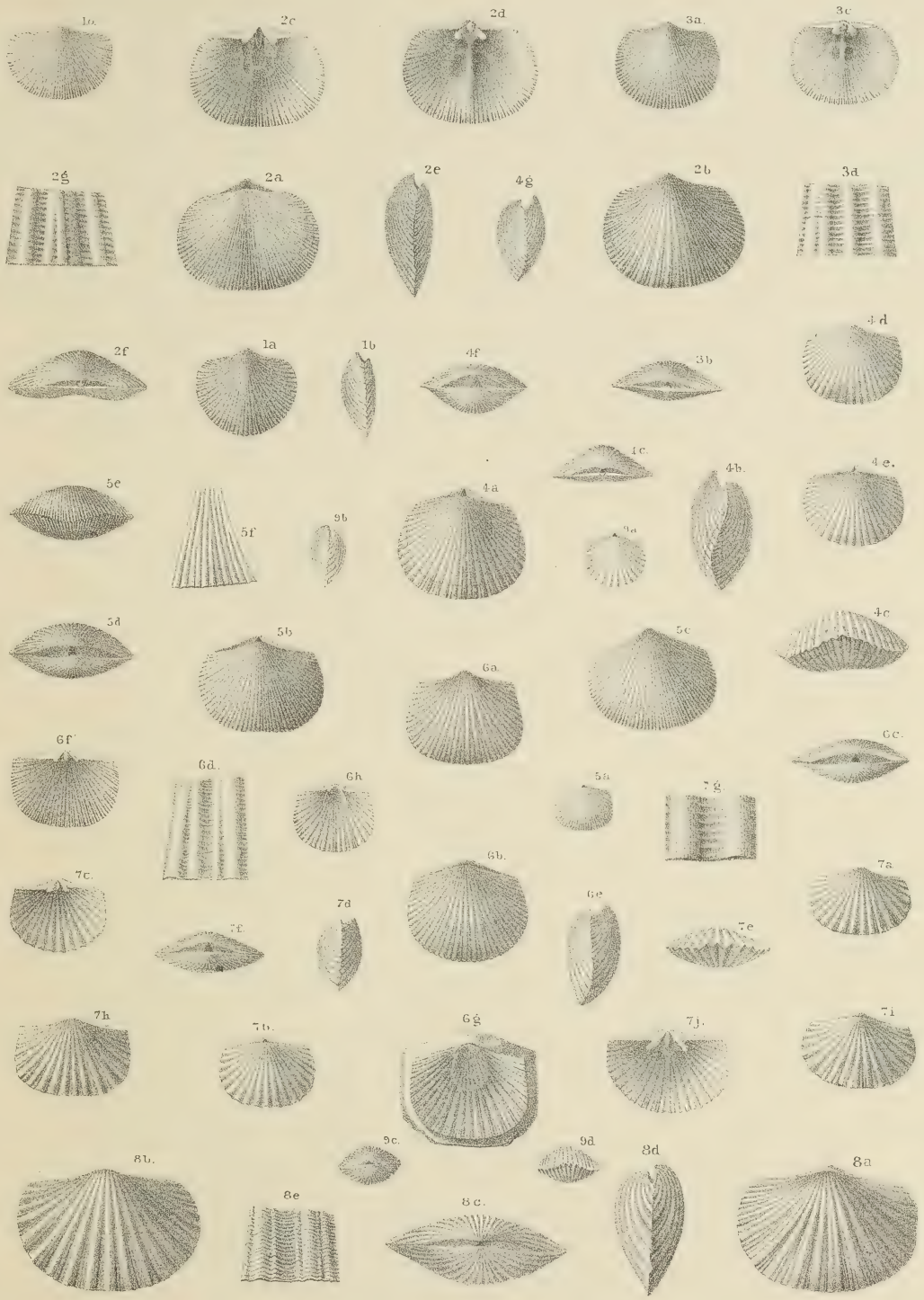

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PLATE IX.

PAGE.

Fig. 1. ORTHIS INSCULPTA 99

1 *a*. Dorsal view.
1 *b*. Ventral view of same.
1 *c*. Interior of dorsal valve, showing cardinal and brachial processes, muscular impressions and vascular markings. Mr. Dyer's collection.
1 *d*. Interior of ventral valve, showing muscular and other internal markings, hinge teeth, etc.
1 *e*. Same view of another specimen differing somewhat in these details.
1 *f*. A cardinal or posterior view, showing the cardinal area, foramen, etc.
1 *g*. Profile of same.
1 *h*. Surface markings, magnified.

Fig. 2. ORTHIS SUBQUADRATA 94

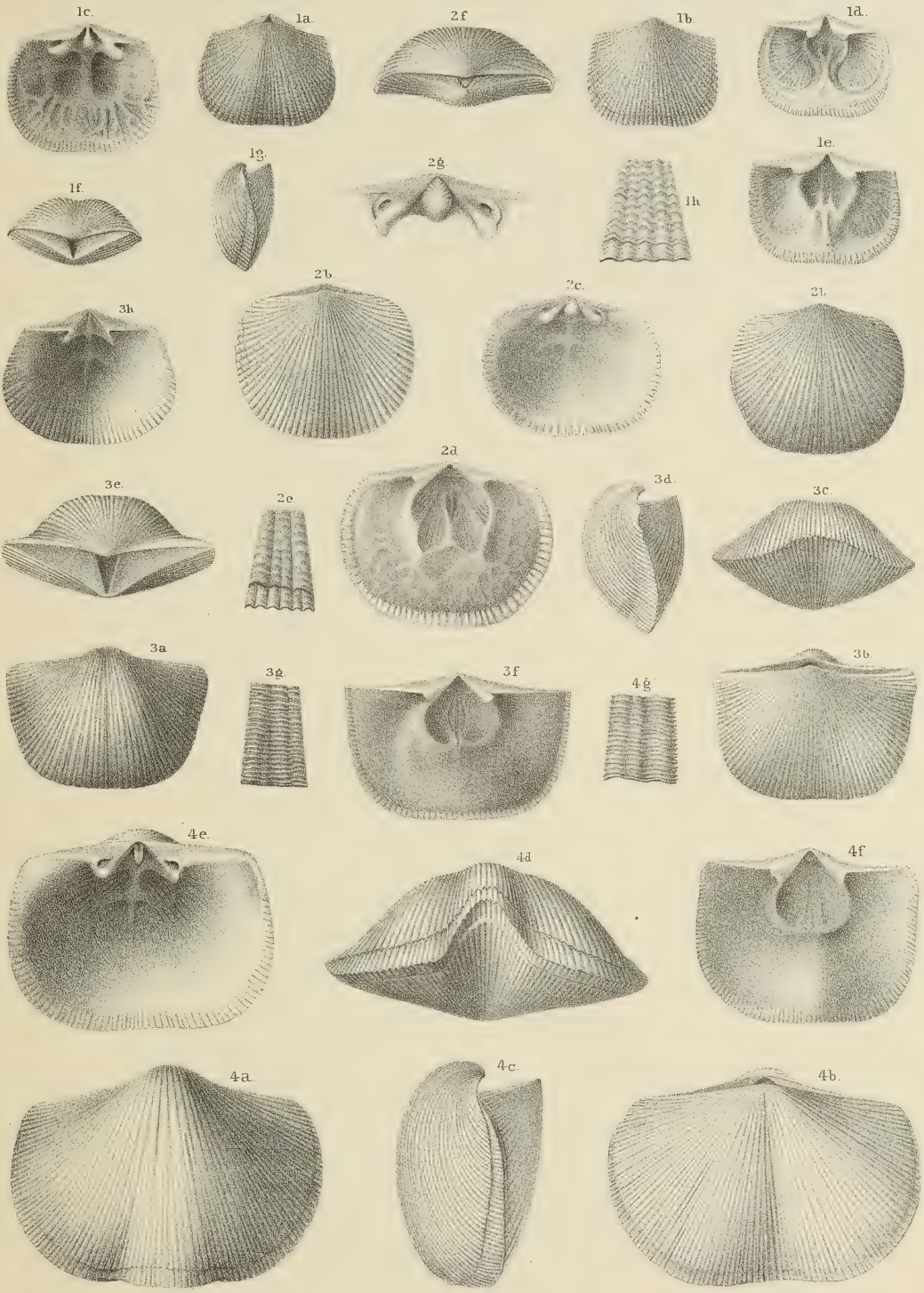
2 *a*. Dorsal view. (*b*, by mistake on the plate.)
2 *b*. Ventral view of same. (Right-hand side of the plate.)
2 *c*. Interior of dorsal valve, showing cardinal and brachial processes, muscular scars, etc.
2 *d*. Interior of ventral valve, showing muscular impressions, hinge teeth, and vascular markings.
2 *e*. Surface markings, magnified.
2 *f*. A cardinal or posterior view.
2 *g*. A part of the cardinal margin, magnified to show the markings on the cardinal process, etc.

Fig. 3. ORTHIS OCCIDENTALIS 96

3 *a*. A dorsal view.
3 *b*. Ventral view.
3 *c*. An anterior view.
3 *d*. A profile or lateral view.
3 *e*. Posterior or cardinal view, showing the high area and foramen.
3 *f*. Interior of the ventral valve, showing muscular scars, hinge teeth, etc.
3 *g*. Surface markings, magnified.
3 *h*. Interior of dorsal valve, showing muscular impressions, and cardinal and brachial processes.

Fig. 4. ORTHIS SINUATA 96

4 *a*. Dorsal view of a large specimen.
4 *b*. Ventral view of same.
4 *c*. Profile of same.
4 *d*. Anterior view of same.
4 *e*. Interior of dorsal valve showing cardinal and brachial process, muscular scars, etc.
4 *f*. Interior of ventral valve, showing muscular impressions, hinge teeth, etc.
4 *g*. Surface markings, magnified.



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Thos Sinclair & Son lith. Phila.

PLATE X.

PAGE.

Fig. 1. ORTHIS (PLATYSTROPHIA) BIFORATA, *var.* LYNX 114

1 *a*. Dorsal view of a medium-sized adult specimen.
1 *b*. Anterior view of same. (This figure should have been drawn with the dorsal valve above, for ready comparison with the same view of the other varieties on this plate.)
1 *c*. Ventral view of same.
1 *d*. A posterior view, showing the double area, foramen, etc.
1 *e*. An internal view of the ventral valve, showing the area, foramen, hinge teeth, and the deep cavity for the muscular scars.

Fig. 2. ORTHIS (PLATYSTR.) BIFORATA, *var.* OF YOUNG..... 117

2 *a*. Dorsal view.
2 *b*. Anterior view of same, showing the very prominent mesial fold and deep sinus.
2 *c*. Posterior view of same.
2 *d*. Ventral view of same.

Fig. 3. ORTHIS (PLATYSTR.) BIFORATA, *var.* DENTATA?..... 117

3 *a*. Dorsal view of a specimen with two plications on the mesial fold and one in the sinus.
3 *b*. A ventral view of same.
3 *c*. Anterior view of same, showing the prominent mesial fold and deep sinus.
3 *d*. A ventral view of another specimen, with a second smaller plication in the sinus and a third on the fold.

Fig. 4. ORTHIS (PLATYSTR.) BIFORATA, *var.* LATICOSTA..... 116

4 *a*. A dorsal view.
4 *b*. Ventral view of same.
4 *c*. Anterior view, showing the prominent mesial fold and deep, wide sinus.
4 *d*. Interior of a ventral valve.
4 *e*. Interior of dorsal valve, showing the obscure muscular scars, very small linear cardinal process, and the tooth-like brachial processes.
4 *f*. The minute granular surface markings, magnified.

Fig. 5. ORTHIS (PLATYSTR.) BIFORATA, *var.* ACUTILIRATA..... 119

5 *a*. Ventral view of a rather large adult specimen.
5 *b*. Posterior view of same, showing the cardinal area and strongly incurved beak of each valve.
5 *c*. Anterior view of same.*
5 *d*. A dorsal view of a more transverse specimen.
5 *e*. Interior of ventral valve, showing the deep cavity for the muscular scars, cardinal area, foramen, and hinge teeth, with a slight thickening and subcrenate appearance of the hinge margin near the teeth. (This latter character may not be normal, as it is not seen in some other specimens.)
5 *f*. A less transverse individual; dorsal view.
5 *g*. Surface granules, magnified. (These granules occur on all of the other varieties, in well-preserved examples.)

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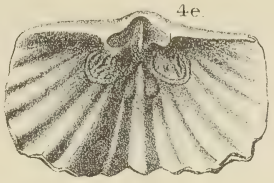
* It may perhaps not be superfluous to inform students, that in comparing this figure and figs 2 *b*, 3 *c*, and 4 *e*, with 1 *b*, that the latter was inadvertently drawn in a different posture from the others, its sinuated valve being turned upward, instead of the reverse.

2a.

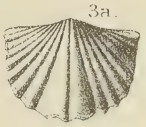
2b.

2c.

2d.


4e.

3c.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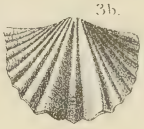
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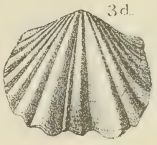
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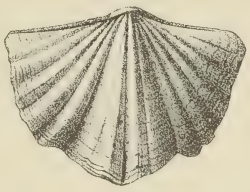
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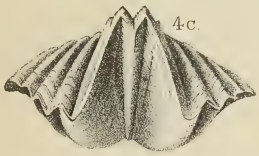
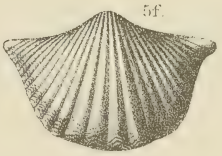
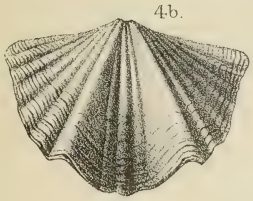

4c.


5f.

5g.

4f.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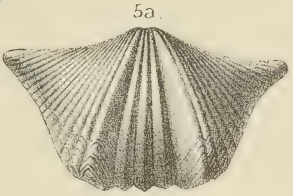
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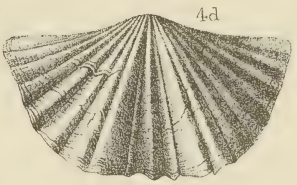
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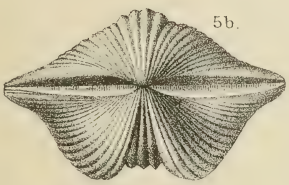
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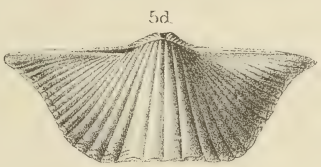
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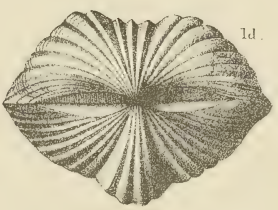
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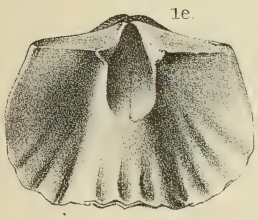
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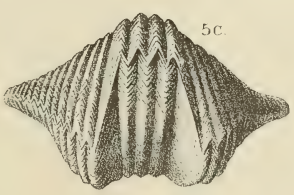
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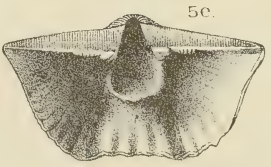
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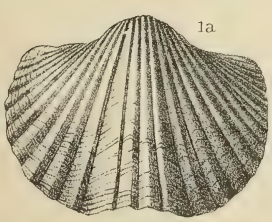
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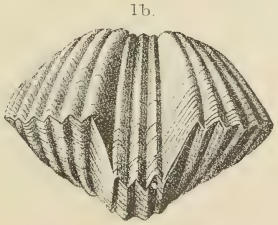
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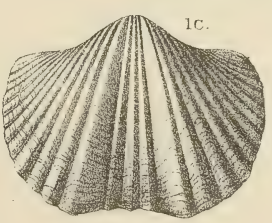
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PLATE XI.

PAGE.

Fig. 1. ZYGOSPIRA HEADI 127

1 *a*. Profile view.
1 *b*. Dorsal view.
1 *c*. Front view.
1 *d*. Ventral view.

Fig. 2. RHYNCHONELLA CAPAX 123

2 *a*. Dorsal view of an adult, rather gibbous specimen.
2 *b*. Front view of same.
2 *c*. Ventral view of same.
2 *d*. Lateral or profile view of a large gibbous specimen.
2 *e*. Interior of ventral valve, showing hinge teeth, and the deep angular cavity for the muscular impressions seen in the bottom of the valve; also the deep rostral cavity.
2 *f*. Interior of dorsal valve, showing the short, closely set apophyses, with the sockets for the reception of the teeth of the other valve, just outside of them. A mesial ridge is seen in the bottom, but no muscular scars have been observed.

Fig. 3. RHYNCHONELLA DENTATA 121

3 *a*. Dorsal view of a specimen with the usual number of muscular plications (two) on the mesial fold.
3 *b*. Lateral view of same
3 *c*. Ventral view of same, showing the single plication in the sinus.
3 *d*. Dorsal view of another specimen having a rudimentary plication somewhat raised on each side of the usual two forming the mesial fold.

Fig. 4. ZYGOSPIRA MODESTA 125

4 *a*. Ventral view of an adult specimen.
4 *b*. Profile of same.
4 *c*. An anterior view of same.
4 *d*. Dorsal view.

Fig. 5. ZYGOSPIRA CINCINNATIENSIS 126

5 *a*. Dorsal view.
5 *b*. Ventral view.
5 *c*. An anterior view.

Fig. 6. RETZIA (TREMATOSPIRA) GRANULIFERA 128

6 *a*. Ventral view. Nat. size
6 *b*. Dorsal view of same.
6 *c*. Profile view of same.
6 *d*. Dorsal view, magnified
6 *e*. A part of two of the plications more highly magnified, to show the surface granulations, with numerous much smaller punctures

Fig. 7. ORTHIS RETRORSA ? 92

7 *a*. Dorsal view.
7 *b*. Ventral view, showing the area strongly inclined forward, and the foramen, with the beak and area of the dorsal valve
7 *c*. A profile view of the same specimen.
7 *d*. Interior of ventral valve of a larger individual, showing the very strongly defined cavity for the muscular scars, and the complex vascular markings. Mr Dyer's collection.
7 *e*. Interior of same valve of a smaller individual, showing same parts, but presenting differences in the form of the cavity for the muscular scars and vascular markings, that seem scarcely compatible with specific identity.
7 *f*. Surface markings, magnified.

Fig. 8. AMBONYCHIA (MEGAPTERA) CASEI ? 133

An external view of right valve, with a part of the alation broken away.

Fig. 9. AMBONYCHIA (MEGAPTERA) ALATA 131

A right valve, with a part of the wing removed. Mr. James's collection.

Fig. 10. CLIDOPHORUS' (NUCULITES) FABULA 138

10 *a*. A left ? side view of an internal cast, magnified 10 diameters
10 *b*. Opposite view of same.

Fig. 11. TELLINOMYA OBLIQUA ? 139

11 *a* and *b*. Right and dorsal views of an internal cast, magnified 10 diameters.
11 *c*. Dorsal view of same.

Fig. 12. CYPRICARDITES STERLINGENSIS ? 133

A right and dorsal views of an internal cast, showing some remains of impressions of posterior hinge teeth at (*t*) of fig. 12 *a*.

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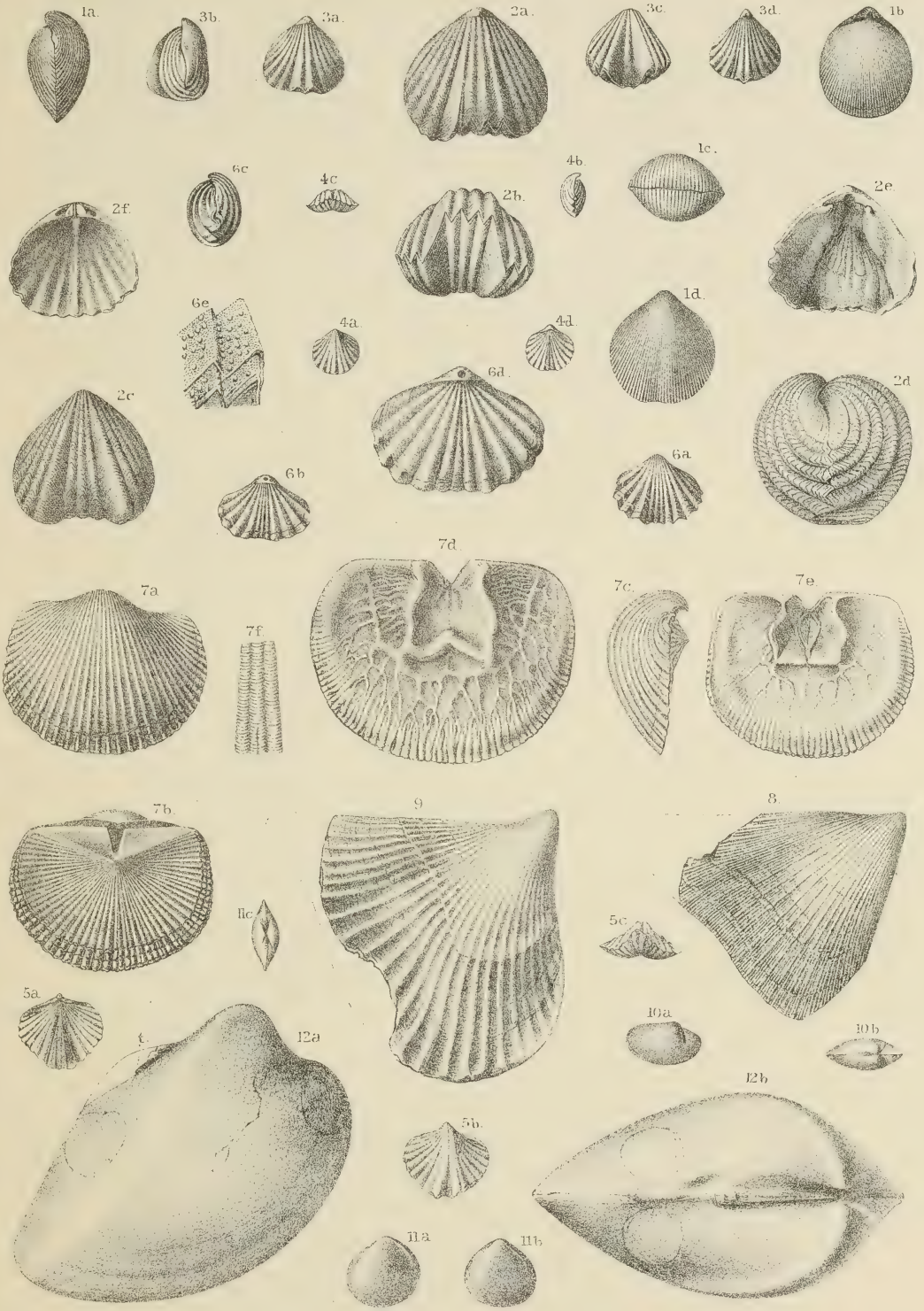
(Cincinnati group.)



W.H.Holmes del.

Th^s Sinclair & Son lith. Phila

PLATE XII.

PAGE.

Fig. 1. ANODONTOPSIS MILLERI 140

1 *a*. Left side view of a medium-sized specimen. Nat. size.
1 *b*. Dorsal view of same
1 *c*. Hinge and interior of left valve of a large specimen, with some of the anterior margin broken away. Mr. Dyer's collection.
1 *d*. Hinge of right valve, with both extremities broken away. A little magnified.

Fig. 2. ANODONTOPSIS UNIONOIDES 141

2 *a*. Dorsal view. Mr. Miller's collection.
2 *b*. Right side view of same specimen.

Fig. 3. SEDGWICKIA ? FRAGILIS 143

3 *a*. Left side view. Nat. size. Mr. James's collection.
3 *b*. Dorsal view of same. Nat. size.

Fig. 4. CARDIOMORPHA ? OBLIQUATA 146

4 *a*. Left side view. Mr. Dyer's collection.
4 *b*. Posterior profile view of same Both natural size.

Fig. 5. AMBONYCHIA COSTATA 130

5 *a*. Left side view. Nat size. Mr. James's collection.
5 *b*. An anterior profile view.
5 *c*. Surface costæ somewhat enlarged, to show the small lines of growth.

Fig. 6. CYPRICARDITES ? CARINATA 135

6 *a*. An anterior view. Nat. size. Mr. Dyer's collection.
6 *b*. A left side view of same. Nat. size. Mr. Dyer's collection.

Fig. 7. SEDGWICKIA ? COMPRESSA 144

7 *a*. A left ? side view. Nat. size. Mr. James's collection.
7 *b*. Dorsal view of same. Nat. size. Mr. James's collection.

Fig. 8. SEDGWICKIA (? GRAMMYSIA) NEGLECTA 142

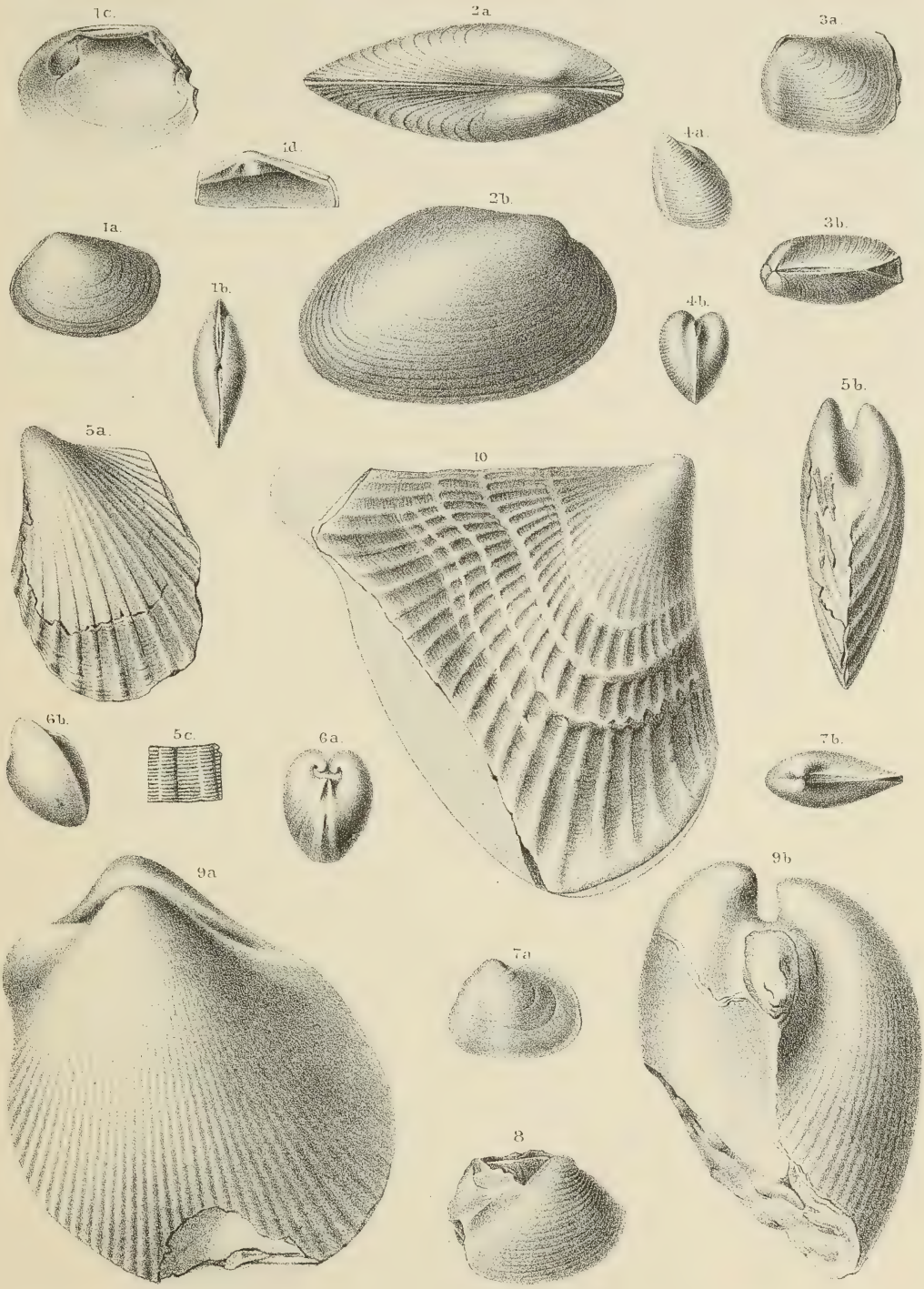
A right side view. Nat. size. Mr. James's collection.

Fig. 9. MEGAMBONIA JAMESI 136

9 *a*. A left side view of an imperfect cast. Nat. size. Mr. James's collection.
9 *b* An anterior view of same.

Fig. 10. AMBONYCHIA (MEGAPTERA) ALATA 131

A right side view of an imperfect specimen. Nat. size Mr. James's collection.



W.H.Holmes, del.

Thos Sinclair & Son, lith. Phila

PLATE XIII.

PAGE.

Fig. 1. CYRTOLITES COSTATUS 150

1 *a*. A side view of a specimen with the shell partly removed, so as to expose the internal cast embedded in the matrix.
1 *b*. Enlargement of a part of the surface, to show the minute transverse striæ between the revolving costæ.
1 *c*. Outline profile, to show the form of a section of the volution near the aperture. Mr. James's collection.
1 *d*. A side view of another specimen, somewhat flattened by lateral pressure, and diff ring from the other in having no large cross ribs. This u ay possibly be distinct from the other. Found by Mr. Klippart.
1 *e*. An enlargement of surface markings of same.

Fig. 2. CYRTOLITES DYERI 149

2 *a*. Side view. Natural size.
2 *b*. Profile view. Natural size.
2 *c*. Side view of same, enlarged to show surface markings.
2 *d*. Side view of another specimen with slightly wider volutions, and somewhat different surface markings.
2 *e*. A profile outline of same. Mr. Dyer's collection.

Fig. 3. CYRTOLITES ORNATUS 148

3 *a*. A side view, natural size, of a gutta-percha cast taken from a natural mould. Mr. James's collection
3 *b*. Enlarged surface markings of same.

Fig. 4. CYRTOLITES (MICROCERAS) INORNATUS 147

4 *a*. Side view. Mag. 6 diameters.
4 *b*. Profile view. Mag. 6 diameters.

Fig. 5. CYCLONEMA BILIX 151

5 *a*. A side view of the typical form of the species.
5 *b*. Enlargement of surface markings of same.
5 *c*. A ventricose variety, with marks of growth very obscure.
5 *e*. Variety *lata*, possibly a distinct species.
5 *f*. Another view of same.
5 *g*. A much elongated variety.

Fig. 6. PLEUROTOMARIA (SCALITES?) TROPIDOPHORA 154

6 *a*. A side view of a specimen enlarged 2 diameters.
6 *b*. An opposite view of same.
6 *c*.

Fig. 7. CYCLORA MINUTA 152

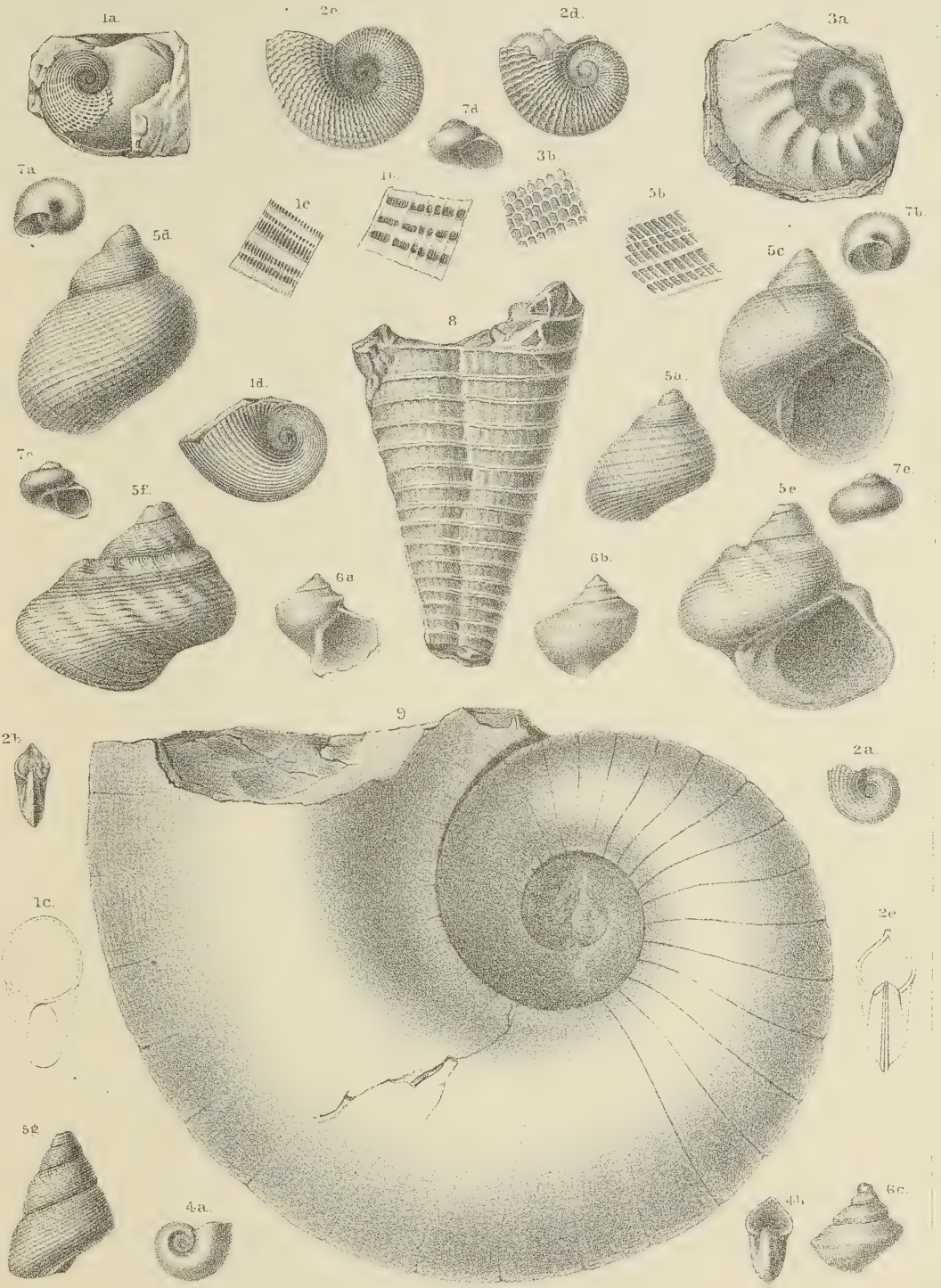
7 *a*. View of under side. Magnified 6 diameters.
7 *b*. Same view of another specimen, with lip more spreading near umbilicus. Magnified 6 diameters.
7 *c*. Side and aperture view. Magnified as above.
7 *d*. Same view of another specimen.
7 *e*. An opposite view of same.

Fig. 8. ORTHOCERAS ORTONI 155

A side view of an imperfect specimen, somewhat flattened by accidental pressure. Mr. Dyer's collection.

Fig. 9. TROCHOCERAS? BAERI 157

A side view of an imperfect specimen. Dr. Baer's collection.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2c.
2d.
3a.
7a.
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3b.
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1e
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1d.
5a.
7c.
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5f.
5e
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9
2b.
2a.
1c.
2e.
5g.
4a.
4b.
6c.

PLATE XIV.

PAGE.

Fig. 1. CYTHERE CINCINNATIENSIS 158

1 *a*. A side view. Magnified about 3½ diameters. Mr. Dyer's collection.
1 *b*. A dorsal view of same specimen.
1 *c*. A lateral view of a large specimen. Magnified 3 diameters. Mr. Dyer's collection.
1 *d*. A dorsal view of same.

Fig. 2. DALMANITES CARLEYI 170

2 *a*. Cephalic shield. Nat. size. Mr. James's collection.
2 *b*. Same, magnified.
2 *c*. The visual surface of one of the eyes, magnified.
2 *d*. Pygidium, probably of the same species, found associated.

Fig. 3. ACIDASPIS CINCINNATIENSIS 167

Pygidium and a part of one of the thoracic segments. Drawn natural size. Mr. Dyer's collection.

Fig. 4. ACIDASPIS 169

A right movable cheek, inside view. Nat. size. Probably belongs to *A. Cincinnatiensis*.

Fig. 5. ACIDASPIS 169

A left movable cheek, apparently of another species, from a higher position in the series. Mr. O'Neall's collection.

Figs. 6 and 7. ACIDASPIS 169

Fig. 6 represents a glabella with the fixed cheeks, nat. size; and fig. 7 the same parts, with the fixed cheeks mainly broken away. These may belong to two species. Both nat. size. Mr. James's collection.

Figs. 8 and 9. ACIDASPIS CERVARIA? 169

Fig. 8. A pygidium apparently without digitations between the two spines.
Fig. 9 differs in having 6 digitations between the two spines. These may belong to distinct species, but they seem to be the same as those for which the above specific name was proposed by Mr. Anthony. Both are drawn natural size. Mr. James's collection.

Fig. 10. ACIDASPIS CROSOTUS 165

10 *a*. A nearly perfect specimen, magnified about 4 diameters. It has the extremities of the pleuræ broken away, and does not show the margins of the cheeks, the supposed outlines of which are indicated by dotted lines, without any attempt to show the digitations of the margins. Dr Miller's collection.
10 *b*. A mould of the exterior of another specimen, apparently of this species. Magnified about 4 diameters. Mr. James's collection.

Fig. 11. CRYPHÆUS 162

11 *a*. A large, nearly perfect specimen. Mrs. Haines's collection.
11 *b*. A lateral view of a nearly entire specimen of smaller size, rolled up. Mr James's collection.
11 *c*. A view from above of the cephalic shield of same.

Fig. 12. PROETUS SPURGERI 161

A specimen with the cephalic shield injured by abrasion and pressure, and slipped slightly backward so as partly to hide one or more of the thoracic segments. Magnified 3 diameters. Mr. Dyer's collection.

Fig. 13. ASAPHUS (ISOTELUS) MEGISTOS? 159

A young, entire specimen.

Fig. 14. CALYMENE SENARIA 173

14 *a*. A view of cephalic shield and a part of the thorax of an unusually fine, perfect specimen. Mr. Shaffer's collection.
14 *b*. A lateral view of same.
14 *c*. An anterior view of same; also showing the pygidium, and the posterior part of thorax.
14 *d*. A specimen showing an inside view of the labrum or hypostome, in place, with an inner view of the rostral shield, and on each side of the latter a little of the margin of the cheeks. All magnified 2 diameters. Mr. Dyer's collection.
14 *e*. An outside view of the labrum. Magnified 2 diameters. Mr. Dyer's collection.
14 *f*. An internal view of two of the body segments, nearly natural size, to show the curious inflected margins of the free ends of the pleuræ, as seen from below.

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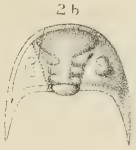
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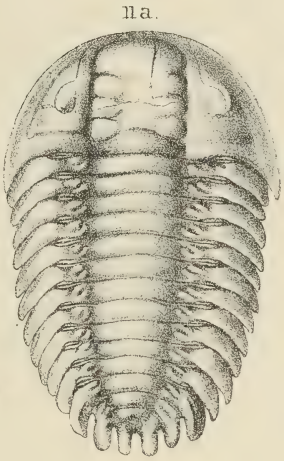
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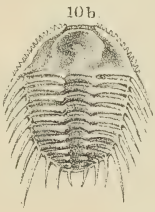
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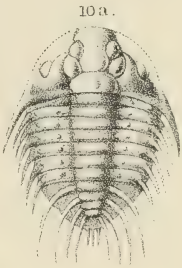
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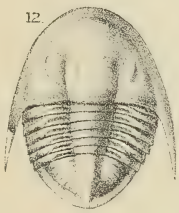
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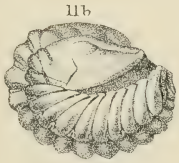
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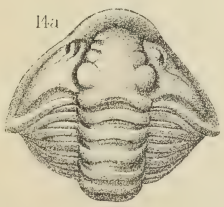
13.

14b.

14f.

14e.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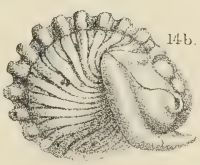
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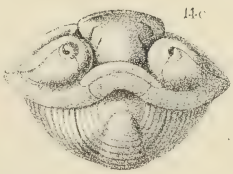
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PLATE XV.

PAGE.

Fig. 1. TRIPLESIA ORTONI 178

1 *a*. A dorsal view of a specimen with the anterior part of the valves broken away.
1 *b*. A side view of the same.
1 *c*. A dorsal valve, with the anterior and portions of the lateral margins broken away.
1 *d*. A posterior view of a portion of the two valves somewhat compressed accidentally, showing the area and small foramen of the ventral valve.
1 *e* A lateral view of an imperfect specimen.
1 *f*. Interior of an imperfect ventral valve, showing the hinge teeth, foramen, etc.
1 *g*. A fragment of the dorsal valve, turned up so as to show the full length of the bifid cardinal process.
1 *h*. A side view of the same, turned as the curvature of the beak would direct the cardinal process.
1 *i*. An inner view of the same part of another specimen, with the cardinal process partly broken away, and the remains of the brachial processes seen on each side.
1 *j*. A part of the ventral valve, including the beak and most of the area, turned so as to show the projection of the hinge teeth beyond the hinge line.
1 *k* An ideal section of the two valves united, showing how the long cardinal process projects within the cavity of the ventral valve.

Fig. 2. MERISTELLA (MERISTINA?) CYLINDRICA 180

2 *a* View of ventral valve of a large specimen, much flattened on each side.
2 *b* Dorsal view of same
2 *c*. Lateral view of same.
2 *d*. A dorsal view of a smaller specimen, less flattened on each side.

Fig. 3. RHYNCHONELLA NEGLECTA?..... 179

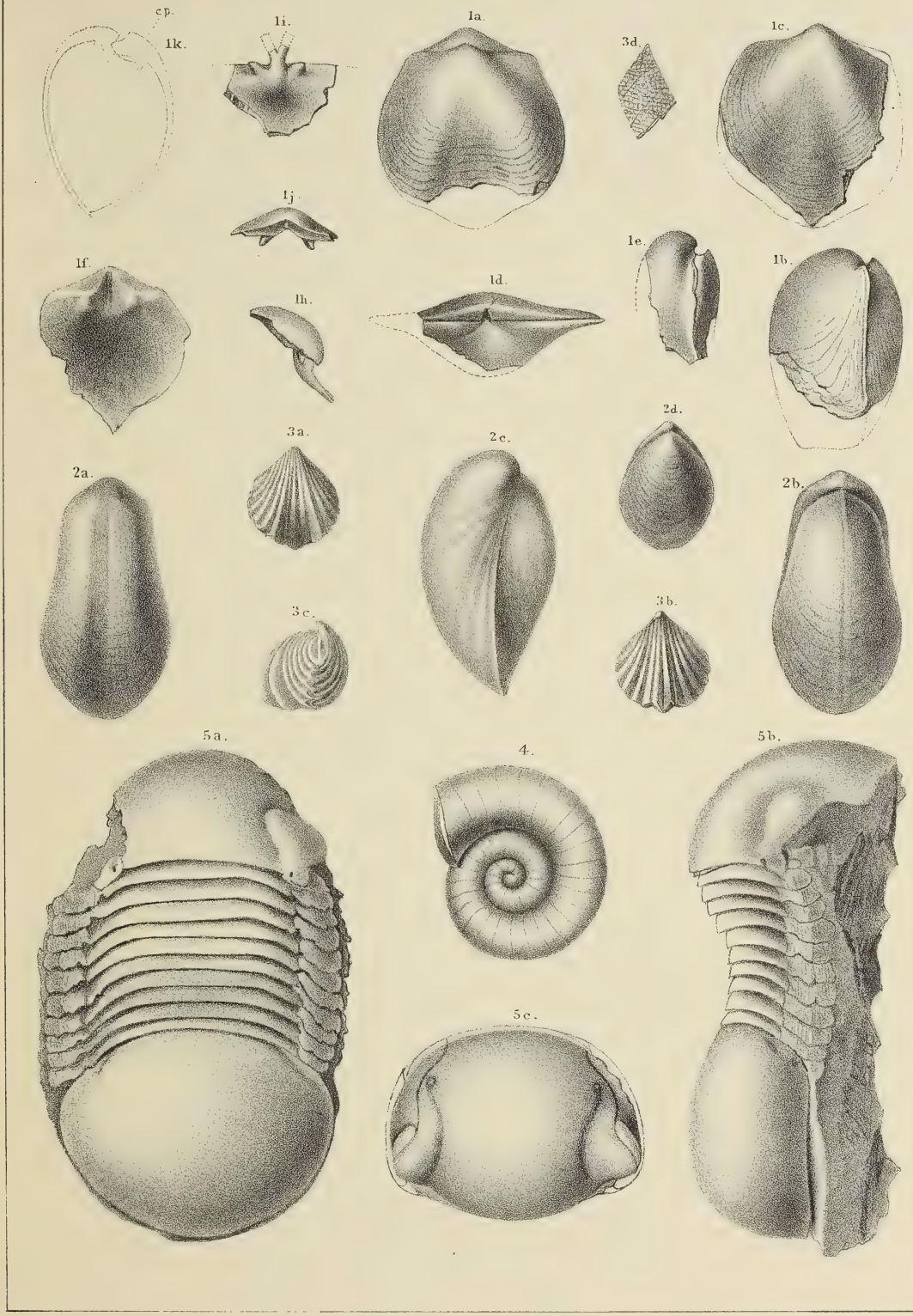
3 *a*. Ventral view of a large gibbous specimen.
3 *b*. Dorsal view of same.
3 *c* Lateral view of same.
3 *d* Granulations of the surface, magnified.

Fig. 4. LITUITES? ORTONI 186

Side view of internal cast, natural size.

Fig. 5. ILLÆNUS INSIGNIS?..... 189

5 *a*. Dorsal view of a nearly entire internal cast; only the lateral portions of the cheeks and parts of the pleuræ being imperfect. The head is bent downward, so as not to show its entire length, as seen from above.
5 *b*. A side view of same.
5 *c*. A separate head of another individual.



Thos Sinclair & Son, lith. Phila.

PLATE XVI.

PAGE.

Fig. 1. TRIMERELLA OHIOENSIS 183

1 *a*. Cast of interior, side views. Nat. size.
1 *b*. Ventral view of internal cast of same.
1 *c*. A posterior view of cast of same.
1 *d*. Dorsal view of same.

Fig. 2. TRIMERELLA GRANDIS 182

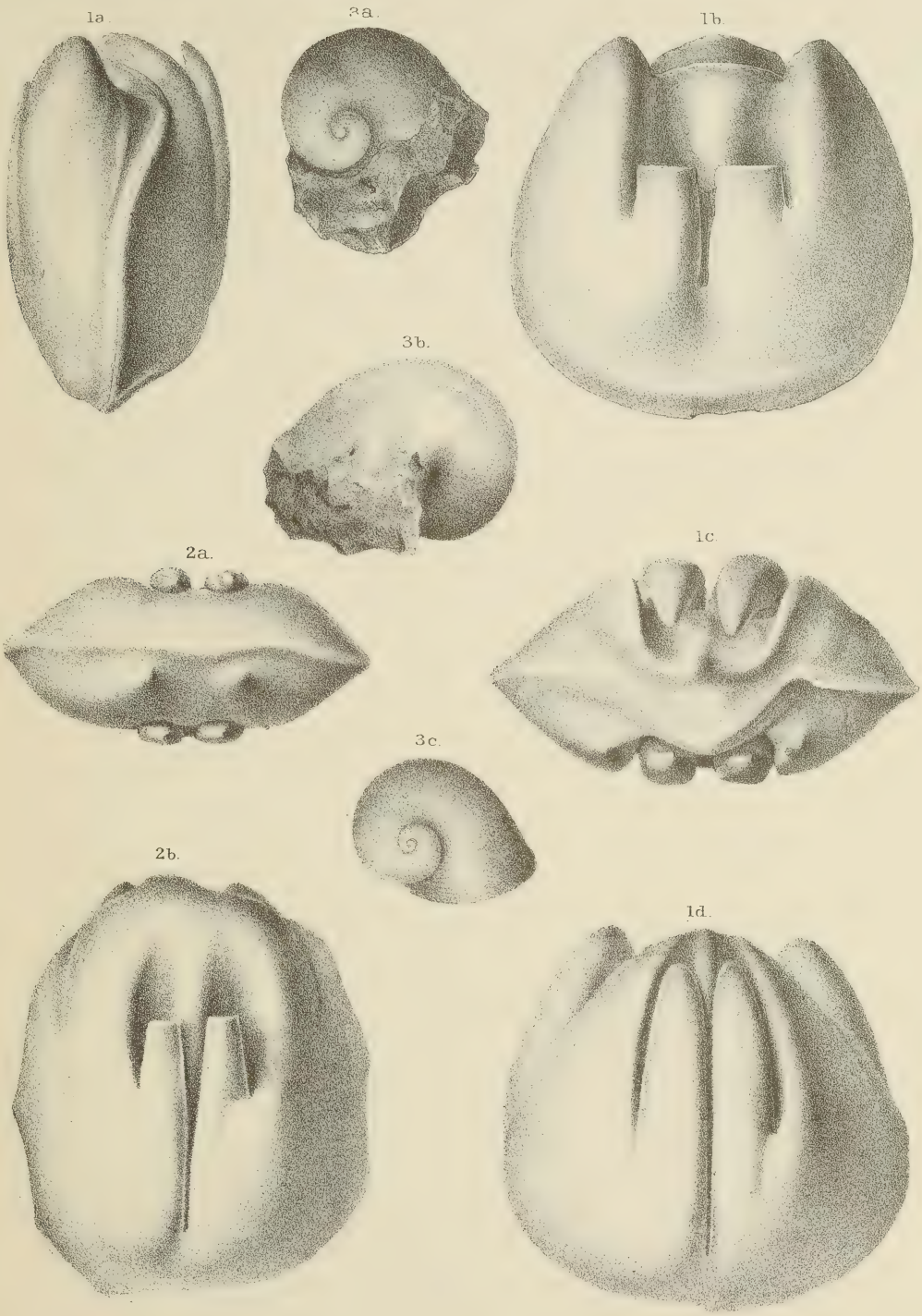
2 *a*. A posterior view of internal cast of the original typical specimen, belonging to the Museum of the Canadian Geological Survey, and figured for comparison with fig. 1 *c*.
2 *d*. A dorsal view of same, for comparison with 1 *d*.

Fig. 3. PLATYOSTOMA TRIGONOSTOMA 185

3 *a*. View of upper side of cast.
3 *b*. View of under side of cast.
3 *c*. View of upper side of a smaller specimen.

Geological Survey of Ohio.

UPPER SILURIAN. (Niagara group.) PLATE 16.



H.W. Elliott, del. Thos Sinclair & Son, lith. Phila.

PLATE XVII.

PAGE.

Fig. 1. XENOPHORA? ANTIQUA 221

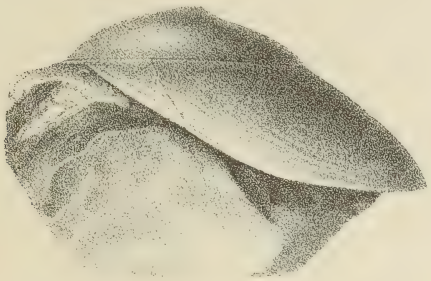
1 *a*. Profile or side view, showing strongly depressed spire, and sharply angular periphery. Nat. size.
1 *b*. Under side of same.
1 *c*. Profile of another specimen.
1 *d*. Upper side of same, showing very oblique costæ obscurely indicated on the cast.
1 *e*. Upper side of the same specimen represented by figures 1 *a*, *b*, and *c*.

Fig. 2. LEPERDITIA ALTA?..... 187

2 *a*. Left valve, magnified 2 diameters.
2 *b*. Right valve, probably of same species, also magnified 2 diameters.

The concentric lines on both figures are only intended to represent shading, the figures being originally intended to be engraved in lines only.

1a.



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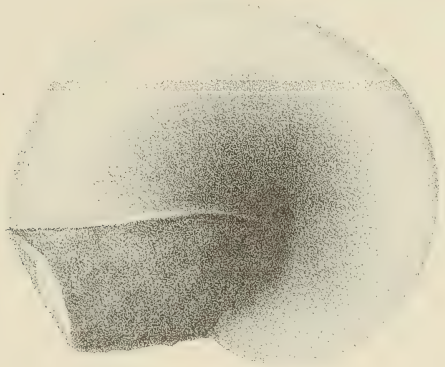

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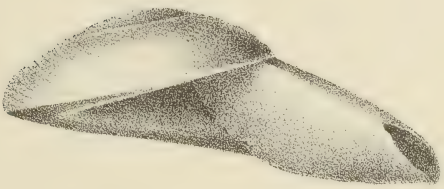
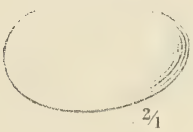


2 a.

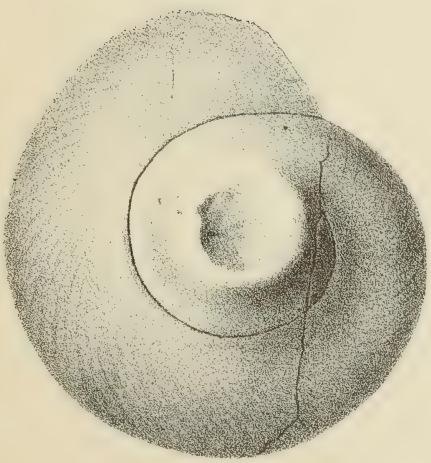
2/1

2 b.



2/1

1d.



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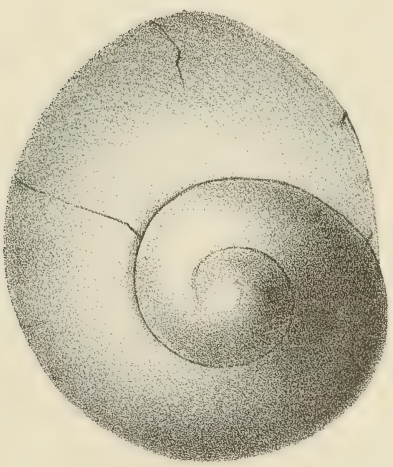


PLATE XVIII.

PAGE.

Fig. 1. PTILODICTYA (STICTOPORA) GILBERTI 194

1 *a*. A piece of this fossil as seen lying in the matrix. Nat. size.
1 *b*. Another specimen of same.
1 *c*. A fragment of one of the branches, much enlarged, to show the pores with their slightly raised margins, and the linear ridges between the rows of pores (*s. s.*). It also shows (at *a*) the transversely striated lamina or axis, exposed by the removal of the poriferous part of that side; while at (*i*) the impression of the opposite poriferous side is seen in the matrix.

Fig. 2. PTILODICTYA 195

A part of a broad expansion several inches in size, consisting of the mesial, wrinkled and striated lamina of a species apparently of this genus, and retaining, at places, some remains of the outer poriferous layer, differing little, if any, in the size and arrangement of the pores, and other surface characters, from the last.

Fig. 3. SANGUINOLITES? SANDUSKYENSIS 209

View of left side of a cast. Nat. size.

Fig. 4. SOLEMYA VETUSTA 206

Left view of an internal cast, retaining some fragments of the thin shell.

Fig. 5. CLINOPISTHA ANTIQUA 208

5 *a*. Left side view of a partly exfoliated specimen, showing remains of the ligament on the shorter side at (*l*).
5 *b* Posterior view of same.

Fig. 6. AVICULOPECTEN PARILIS? 197

6 *a*. View of left valve.
6 *b*. Another of same, of larger size.

Fig. 7. LUCINA (PARACYCLAS) OHIOENSIS 199

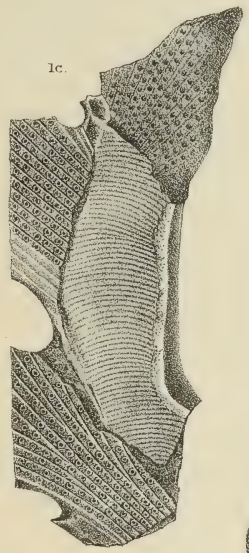
7 *a*. A small specimen. Nat. size.
7 *b*. A larger individual, differing in form, but probably the same species. Its posterior dorsal margin is broken away, and restored in outline.

Fig. 8. RHYNCHONELLA CAROLINA 196

8 *a*. Dorsal view of a small specimen.
8 *b*. Ventral view of same.
8 *c*. Dorsal view of a larger individual.
8 *d*. Ventral view of same. (The mesial fold should be more defined in this figure.)
8 *e*. Profile of same.

Fig. 9. CONOCARDIUM OHIOENSE 203

Side view of a specimen defective at anterior basal margin.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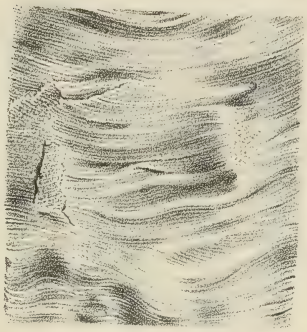
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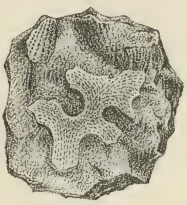
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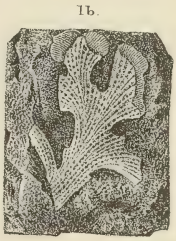
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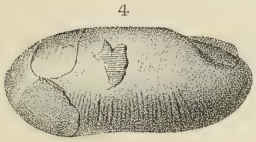
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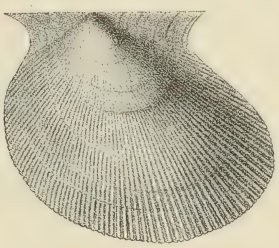
7b.

7a.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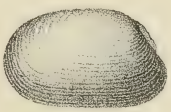
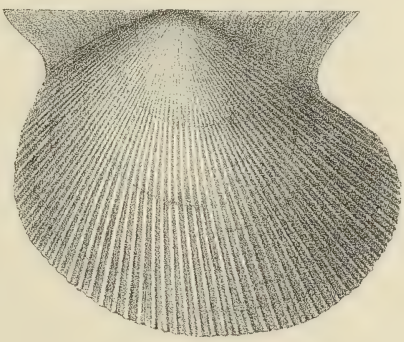

5a.

9

8c.

8a.

5b.


6b.

8b.

8d.

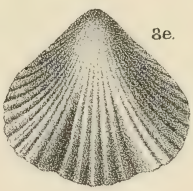

8e.

PLATE XIX.

PAGE.

Fig. 1. ISONEMA HUMILIS 214

1 *a*. View of the upper side of a specimen consisting mainly of a cast of the interior, with portions of the shell attached.
1 *b* A profile view of the same, showing the broad, flattened inner top (at *l*) partly covered by the rock filling the aperture.
1 *c*. A view of the upper side of another specimen retaining the shell, and showing the surface markings.

Fig. 2. CYCLONEMA CRENULATA 213

2 *a*. Side view. Nat. size.
2 *b*. Same, magnified.
2 *c*. View showing the aperture. Nat. size.
2 *d*. Same, magnified.

Fig. 3. EUOMPHALUS DECEWI 220

3 *a*. View of upper side of a very large, fine specimen. Nat. size.
3 *b*. Profile of same, with its under side attached to the matrix.

Fig. 4. NATICOPSIS LEVIS 215

4 *a*. Dorsal side view. Nat. size
4 *b*. View of opposite side, showing aperture.

Fig. 5. TROCHONEMA TRICARINATA 218

5 *a*. Dorsal side view. Nat. size.
5 *b*. View of opposite side, showing form of aperture, the large umbilicus, etc.

Fig. 6. MURCHISONIA OBSOLETA 218

6 *a*. Aperture—side view. Nat. size.
6 *b*. Dorsal side view.

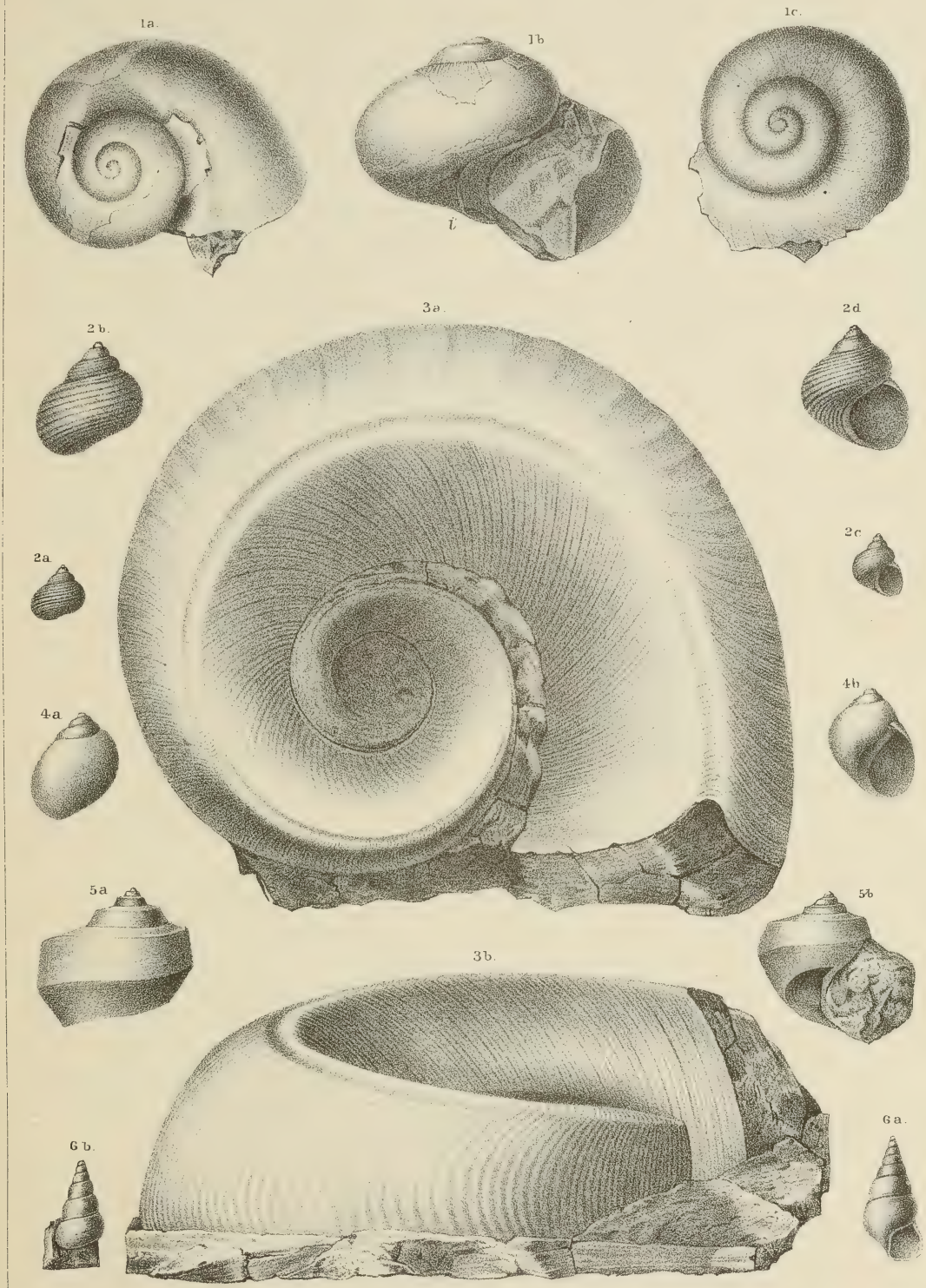

1a.
1b
1c.
t
3a.
2b.
2d
2a.
2c
4a.
4b
5a
5b
3b.
6b.
6a.

PLATE XX.

PAGE

Fig. 1. EUOMPHALUS DECEWI 220

A view of the upper side of a medium-sized specimen, as seen lying in the matrix.

Fig. 2. PLATYCERAS ATTENUATUM 212

2 *a*. An internal cast, showing little nodes that occupied depressions on the inner surface, corresponding to surface spines.

2 *b*. A different view of another specimen, also an internal cast.

Fig. 3. ORTHONEMA NEWBERRYI 217

3 *a*. Dorsal side view. Natural size.

3 *b*. Same magnified, to show surface markings.

Fig. 4. BELLEROPHON NEWBERRYI 222

4 *a*. Side view of a specimen with the lip broken away.

4 *b* A dorsal view of same, showing the fine curved striæ, and very narrow dorsal band.

Fig. 5. BELLEROPHON PROPINQUUS 226

A specimen seen lying in the matrix so as to expose the aperture and the thickened lip spread over the umbilicus on each side as well as the stronger and less curved striæ than those seen on fig. 4.

Fig. 6. PLEUROTOMARIA LUCINA? 226

A specimen consisting of a cast of the interior, with portions of the very thin shell attached.

Fig. 7. PLATYCERAS MULTISPINOSUM 210

7 *a*. An internal cast, showing irregularities corresponding to the spines of the exterior, some remains of the bases of which are seen in a part of the matrix remaining attached to the left side of the specimen. (This figure is defective, in having the nodes marking the position of spines too much like *pits*, and very much too scattering.)

7 *b*. A profile view of another specimen; also a cast of the interior, with a little of the shell near the apex remaining. It is not turned so as to show the greatest length of the shell.

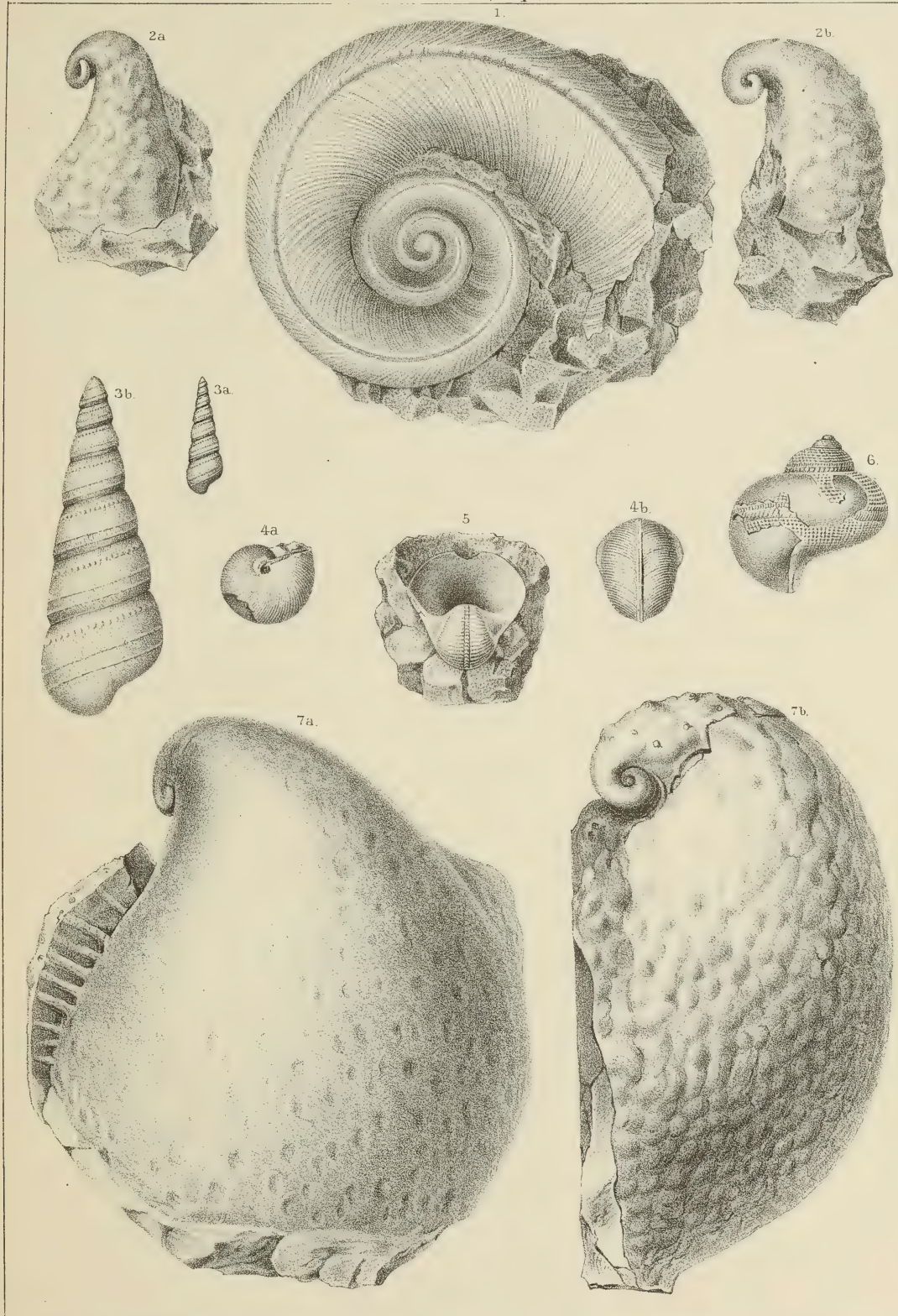
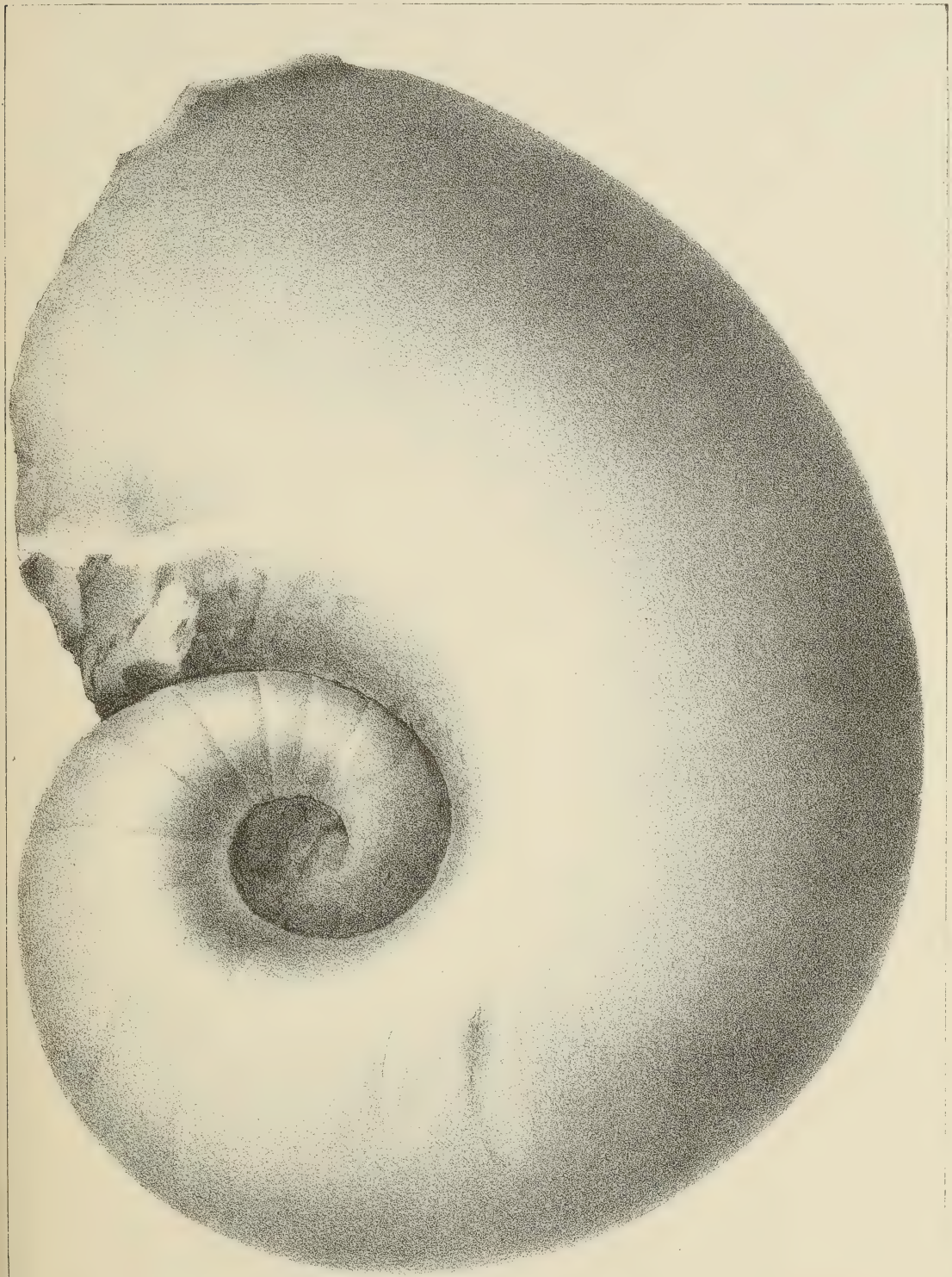

1.
2a.
2b.
3a.
3b.
4a.
4b.
5.
6.
7a.
7b.

PLATE XXI.

PAGE.

Fig. 1. GYROCERATITES? INELEGANS 232

A cast of the interior, reduced about ¼ diameter in size.



H.W. Elliott, del.

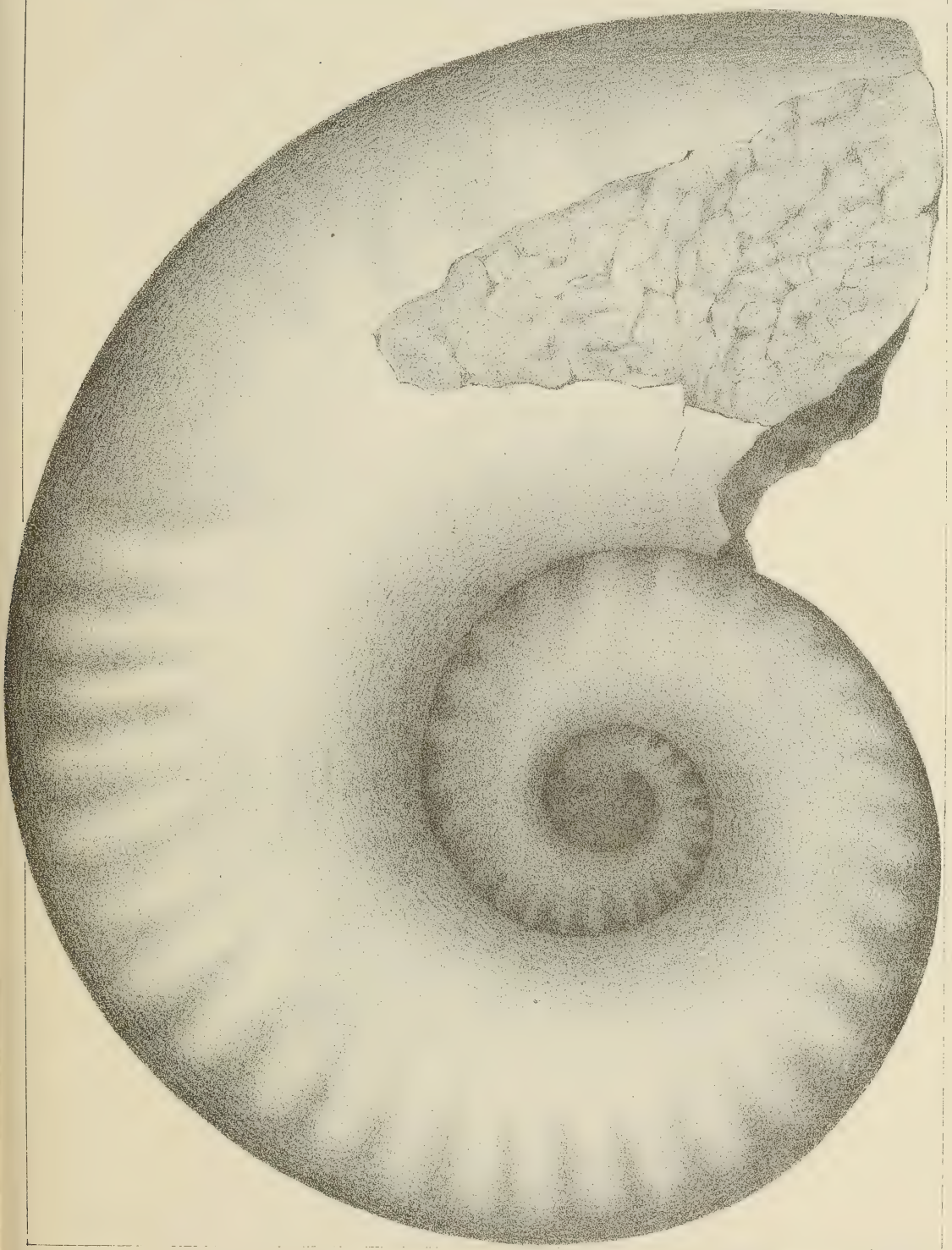
Thos Sinclair & Son, lith., Phila.

PLATE XXII.

PAGE.

Fig. 1. GYROCERATITES OHIOENSIS..... 230

A side view of a natural cast. Natural size.



J. C. M. Connell, del.

PLATE XXIII.

PAGE.

Fig. 1. DALMANITES OHIOENSIS 234

Pygidium drawn from a gutta-percha cast taken in a natural mould.

Fig. 2. CYRTOCERATITES OHIOENSE 229

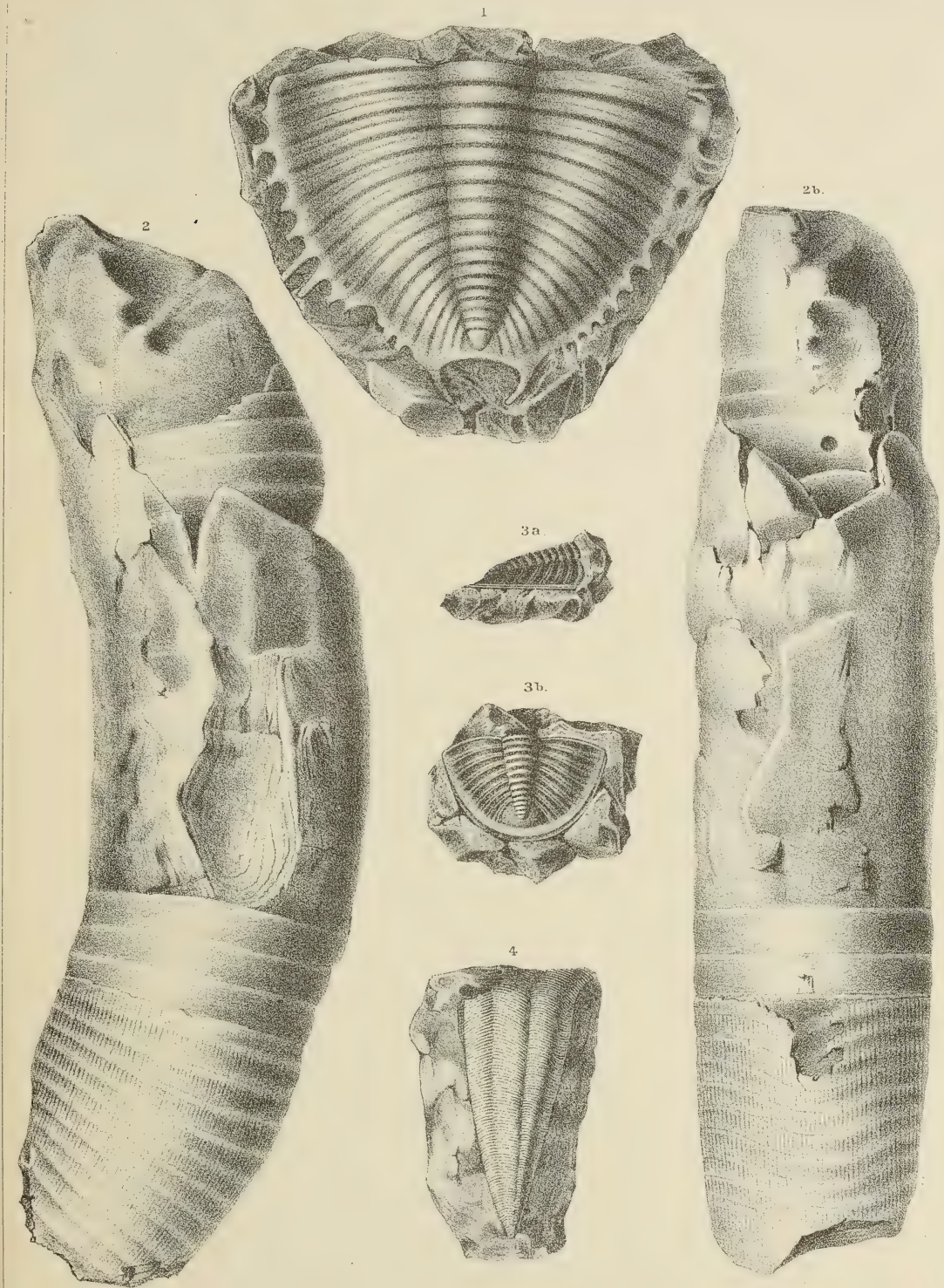
2 *a*. A side view of an internal cast, with portions of the shell attached, and both extremities broken away.
2 *b*. A ventral view of the same.

Fig. 3. PROETUS PLANIMARGINATUS 233

3 *a*. A side view of a cast of the pygidium.
3 *b*. A view of same from above.

Fig. 4. CONULARIA ELEGANTULA 228

A view of a part of the shell as seen lying in the matrix.



H.W. Elliott, del. Thos Sinclair & Son lith. Phila A.J. Ibbotson.

PLATE XXIV.

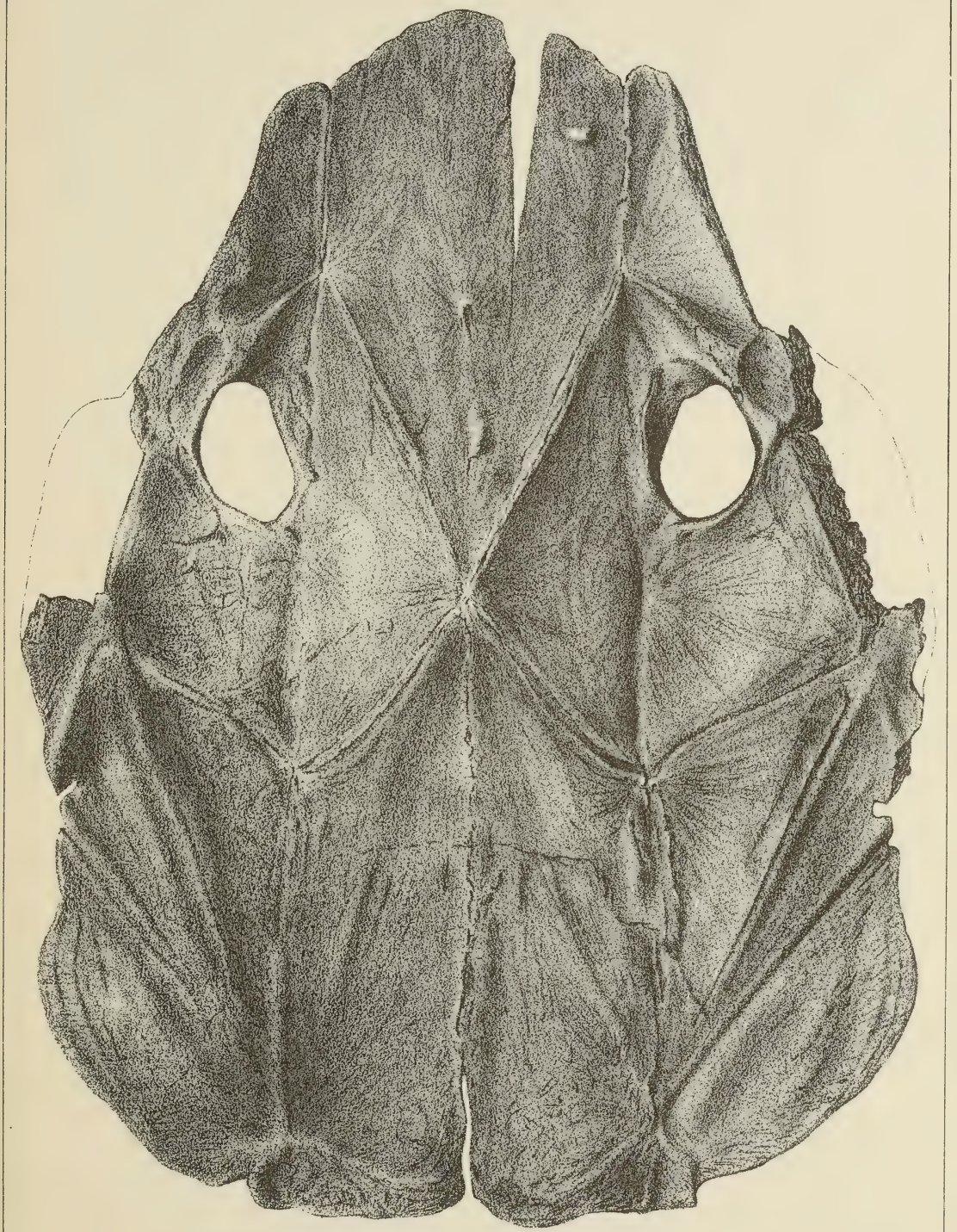
PAGE.

Fig. 1. MACROPETALICHTHYS SULLIVANTI. Newb..... 294

View of under side of cranial plates. Natural size.

Corniferous limestone, Sandusky, Ohio.

The specimen from which this drawing was made belongs to Dr. A. H. Agard, of Sandusky.



G. K. Gilbert, del.

Thos Sinclair & Son, lith., Phila

PLATE XXV.

PAGE.

Fig. 1. MACROPETALICHTHYS SULLIVANTI. Newb..... 294

Side view of cranium, external surface.

1 *a*. Group of dermal tubercles enlarged to twice natural size.

Fig. 2. MACHÆRACANTHUS MAJOR. Newb..... 304

Natural size.

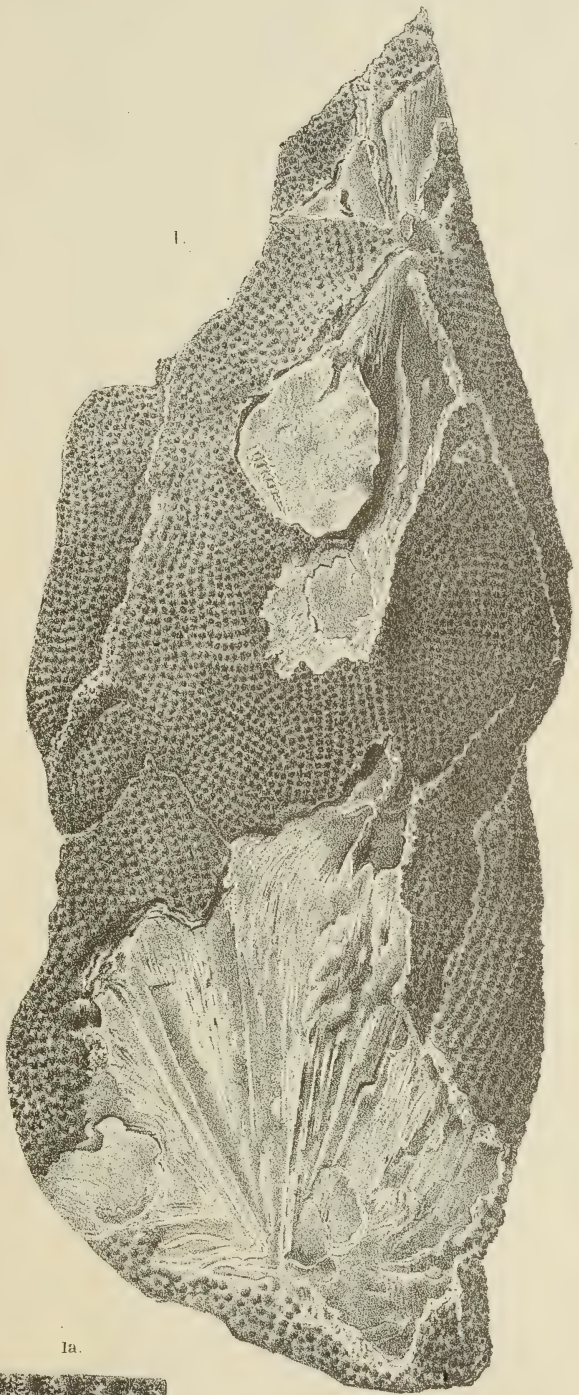
2 *a*. Section of same.

All from the Corniferous limestone, Sandusky, Ohio.

Geological Survey of Ohio.

(Corniferous.)

1.



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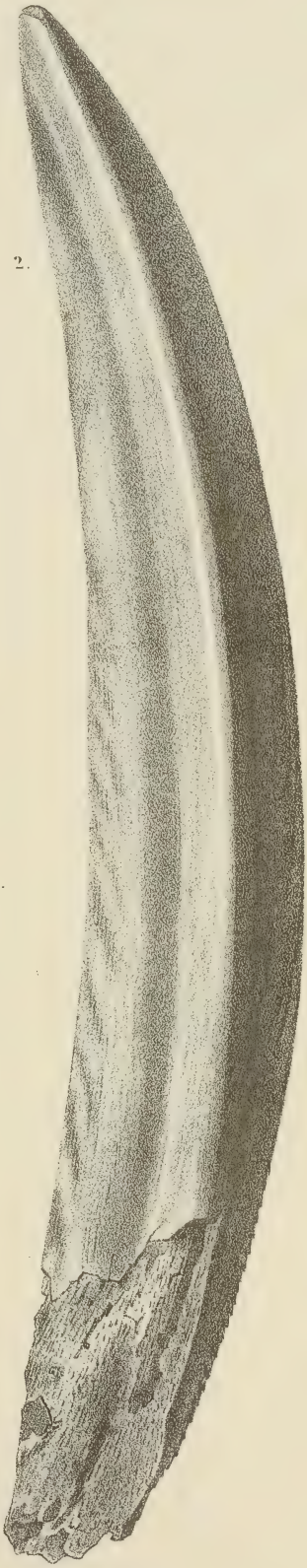

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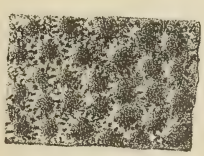


2a.

Thos Sinclair & Son, lith., Phila.

G. K. Gilbert, del.

PLATE XXVI.

PAGE.

ONYCHODUS SIGMOIDES. Newb. 299

Fig. 1. Inter-mandibular crest with three teeth, natural size, from same individual as mandible, Plate XXVII., Fig. 1.

Fig. 2. Detached tooth of mandibular crest. Natural size.

Fig. 3. Inter-mandibular crest with six of the seven teeth in position. This crest belongs with mandibles 4 and 5.

Fig. 4. Exterior face of right mandible of a small individual.
4 *a*. Transverse section of the same.

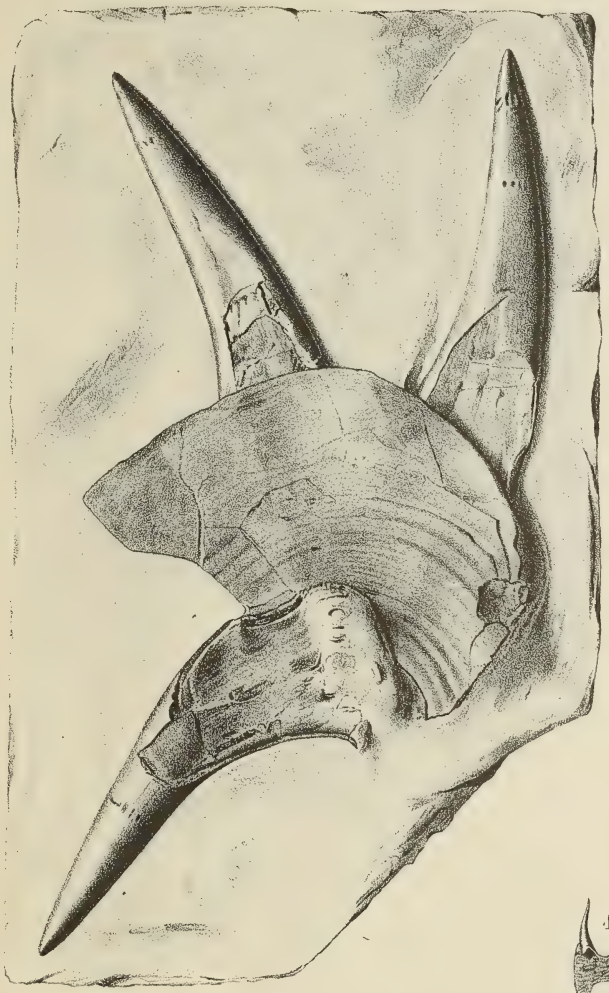
Fig. 5. Exterior face of left mandible belonging with Fig. 4.

All from the Corniferous limestone, Delaware, Ohio.

Geological Survey of Ohio.

(Carniferous.)

1

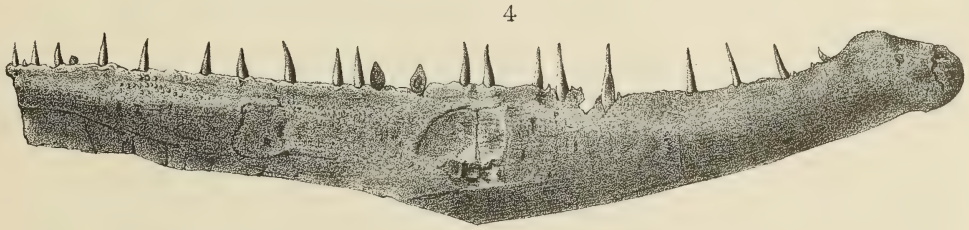


2

3

4a

4



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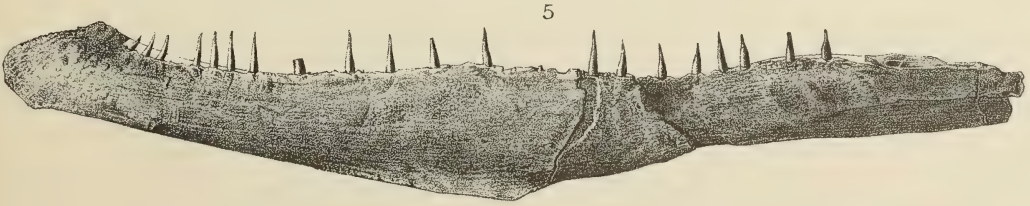


PLATE XXVII.

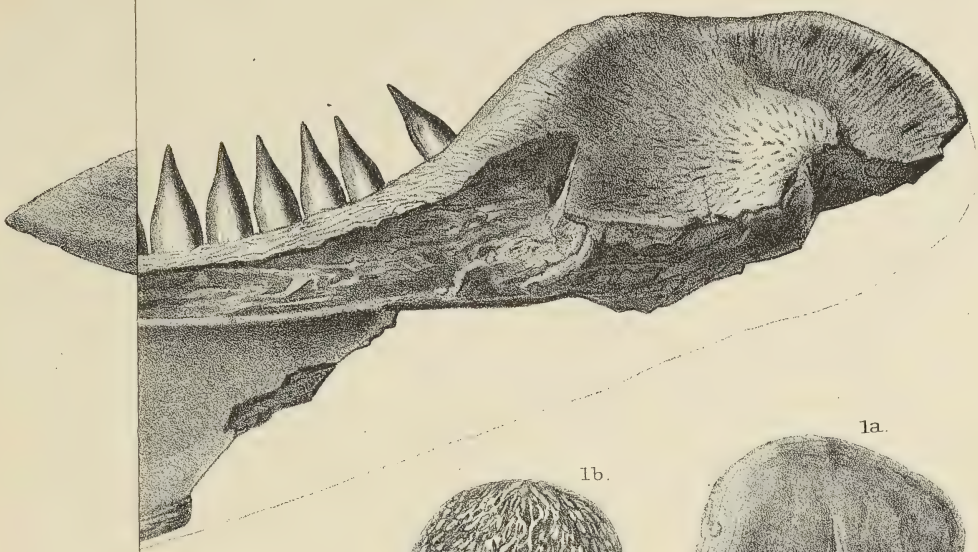
PAGE.

ONYCHODUS SIGMOIDES. Newb 299

Fig. 1. Mandible, inside view.
1 *a*. Scale, inside.
1 *b*. Scale, outside, showing exposed and covered portions of surface; outline restored.
1 *c*. Surface of scale enlarged to show ornamentation.

Fig. 2. Mandible, outside view, showing ornamented surface and three of the series of large teeth embraced in the symphysis of the jaw nearly in position.
2 *a*. Dermal surface of mandible enlarged.

All except 1 *c* and 2 *a* natural size. Corniferous limestone, Delaware, Ohio.



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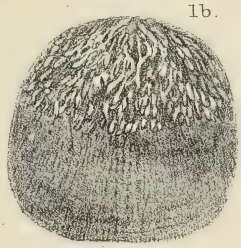

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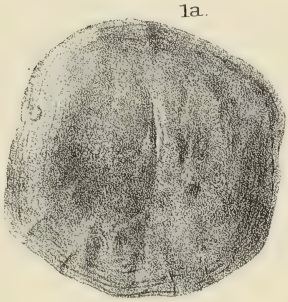

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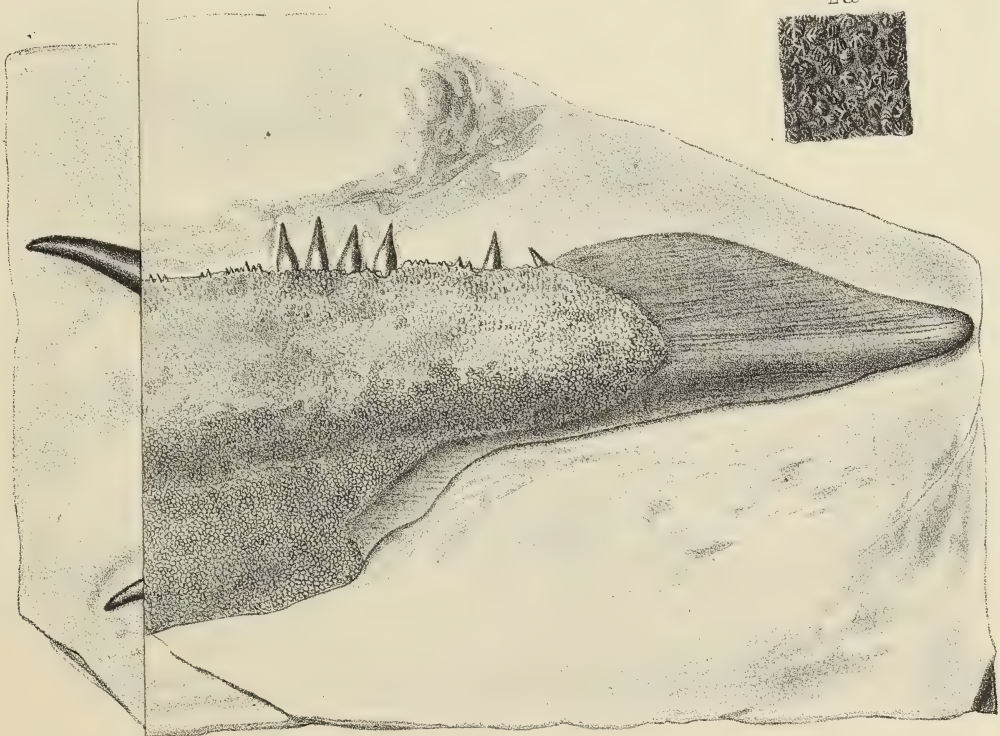


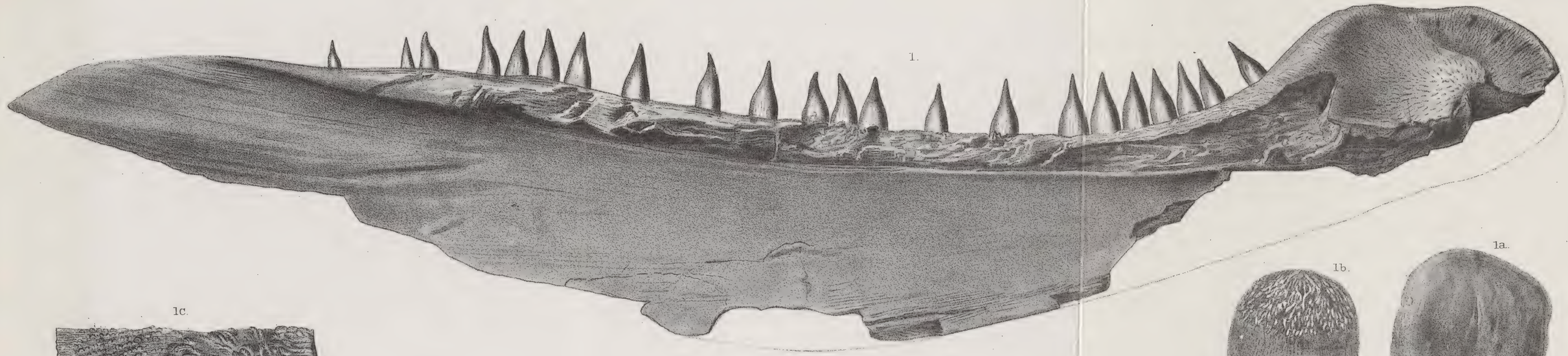
G.K. Gilbert, del.

Thos Sinclair & Son, lith. Phila.

Geological Survey of Ohio.

(Corniferous Limestone.)

1.



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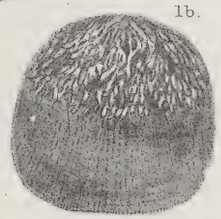
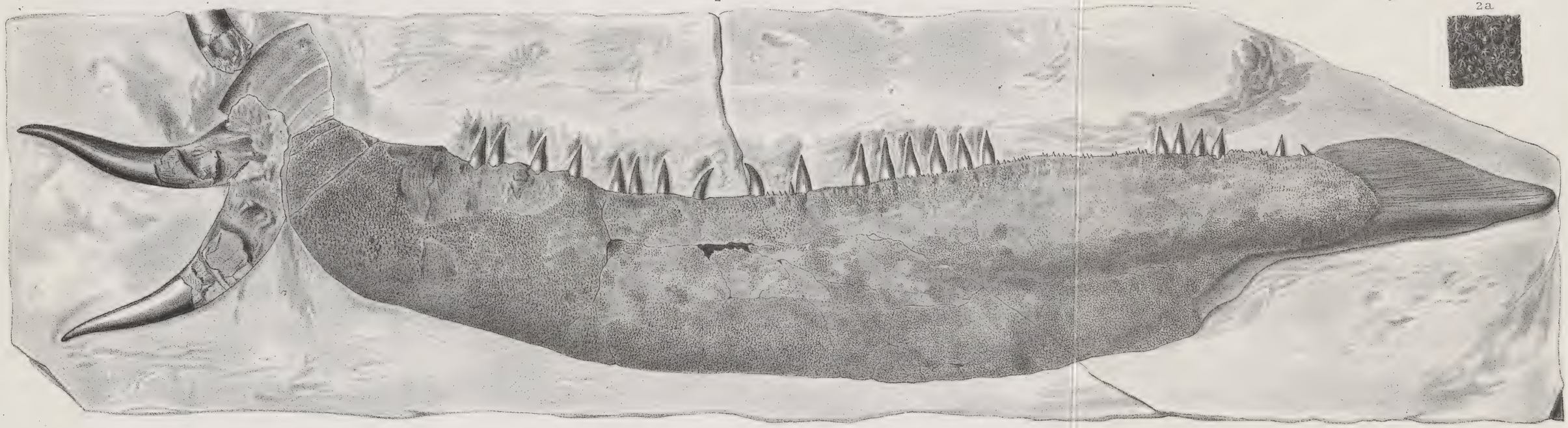
1b.



1c.

2



2a.

G. K. Gilbert, del.

Th^s Sinclair & Son, lith. Phila.

PLATE XXVIII.

PAGE.

Fig. 1. RHYNCHODUS SECANS. Newb..... 310

Upper ? tooth, showing worn cutting edge. Natural size.

1 *a*. Vertical section of Fig. 1, one-third the distance from front.

Fig. 2. RHYNCHODUS FRANGENS. Newb..... 311

External face of left ? lower ? mandibular tooth. Natural size.

2 *a*. Triturating surface of Fig. 2.

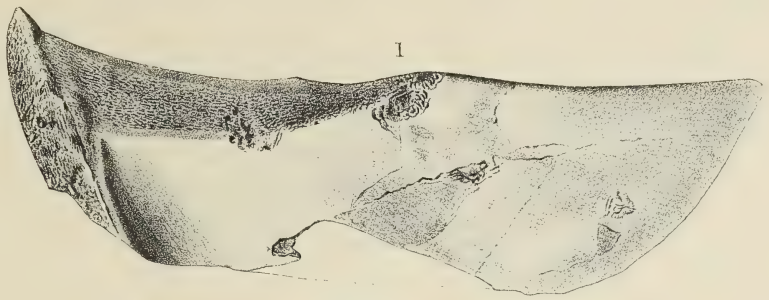
Fig. 3. RHYNCHODUS FRANGENS. Newb..... 311

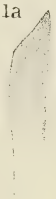
Interior face of anterior crown portion of tooth similar to Fig. 2.

Fig. 4. RHYNCHODUS SECANS. Newb 310

Tooth ?

All from Corniferous limestone, Delaware, Ohio.





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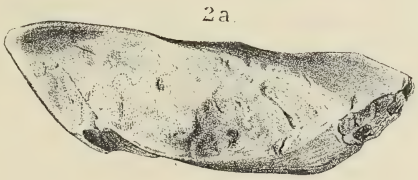

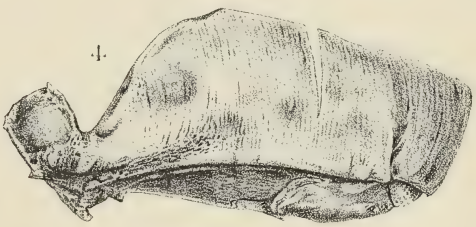

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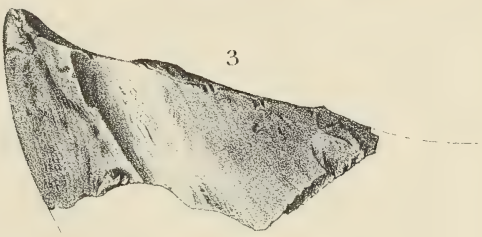

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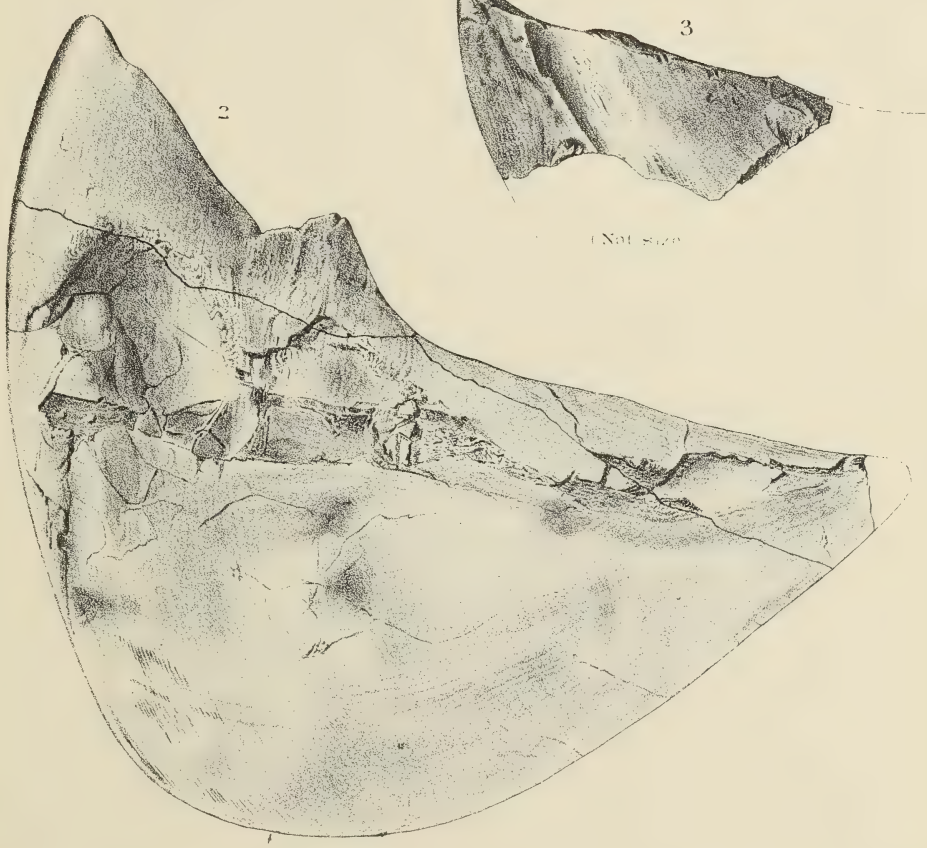


PLATE XXIX.

PAGE.

Fig. 1. RHYNCHODUS SECANS. Newb. 310

Upper mandibular tooth.
1 *a*. Outline of anterior angle of upper mandibular tooth worn by use.
1 *b*. Another form of the same.
1 *c*. Another form of the same.

Fig. 2. RHYNCHODUS SECANS. Newb. 310

Lower mandibular tooth.
2 *a*. Outline of anterior angle of another tooth, somewhat worn.

Fig. 3. RHYNCHODUS CRASSUS. Newb. 312

Lower ? mandibular tooth considerably worn, seen from the inside, showing triturating surface.

Fig. 4. LIOGNATHUS SPATULATUS. Newb. 306

Mandible, interior face.

Fig. 5. CYRTACANTHUS DENTATUS. Newb. 307

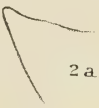
Fig. 6. MACHÆRACANTHUS PERACUTUS. Newb. 305

6 *a*. Section of the same.

All natural size. Originals from Corniferous limestone, Sandusky and Delaware, Ohio.

1

1a.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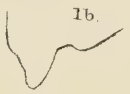
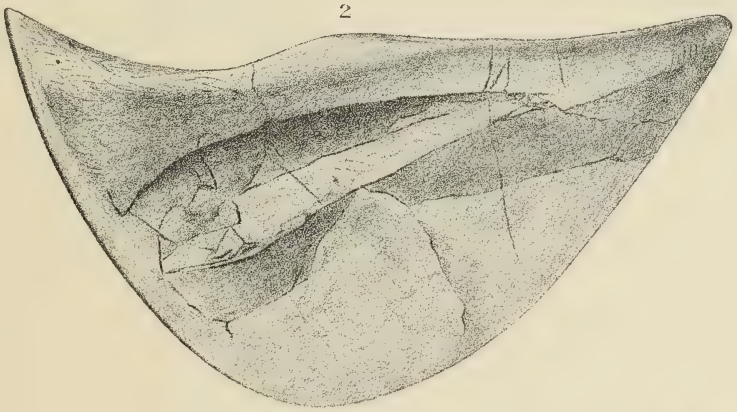

1b.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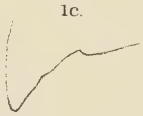
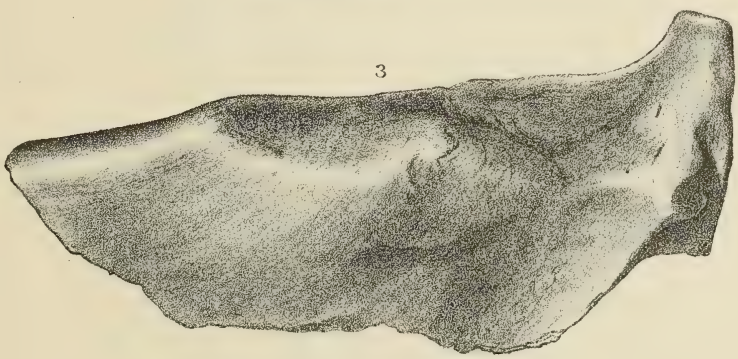

1c.

6a.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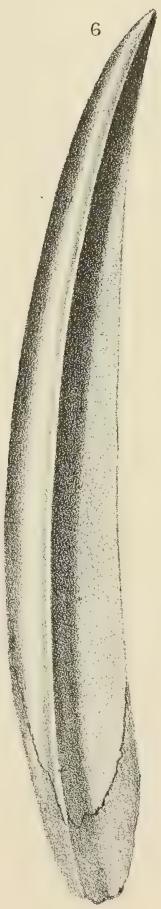
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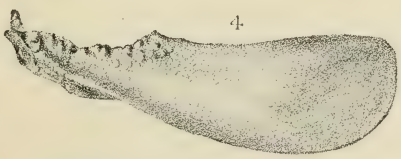
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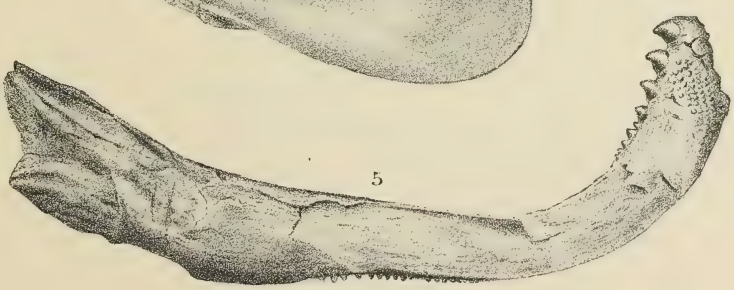

5

PLATE XXX.

PAGE.

DINICHTHYS HERTZERI. Newb..... 316

Fig 1. Mandible showing interior face, one-third natural size, linear. Original two feet in length.

Fig. 2. External face of Fig. 1, one-third natural size.

From concretions in Huron Shale, Delaware, Ohio.

C. K. Gilbert, del.

Thos Sinclair & Son, lith. Phila

PLATE XXXI.

PAGE.

DINICHTHYS HERTZERI. Newb. 316

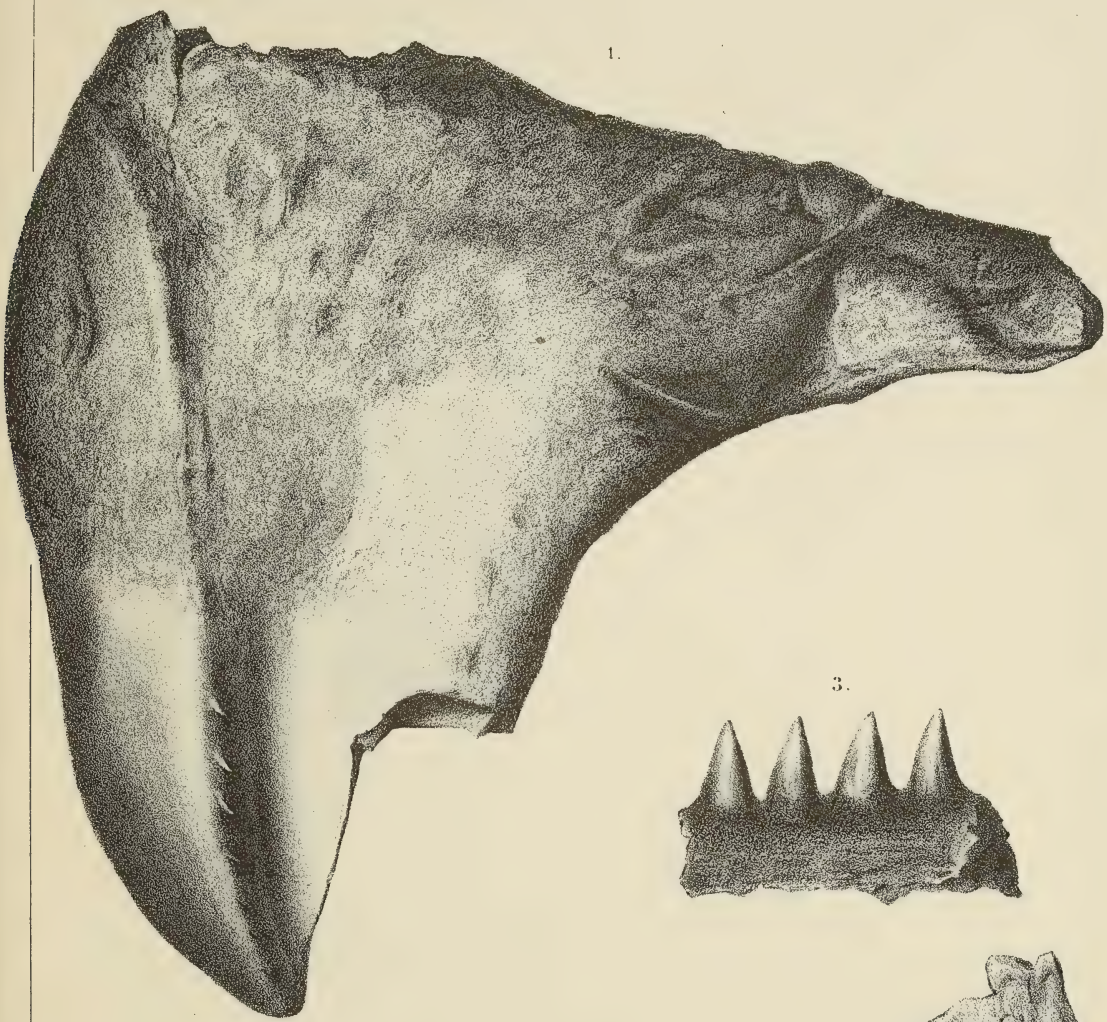
Fig. 1. Premaxillary tooth of left side; lateral view.

Fig. 2. Vertical view of Fig. 1.

Fig. 3. Teeth from central portion of mandible.

All natural size. Huron Shale, Delaware and Monroeville, Ohio.

1.



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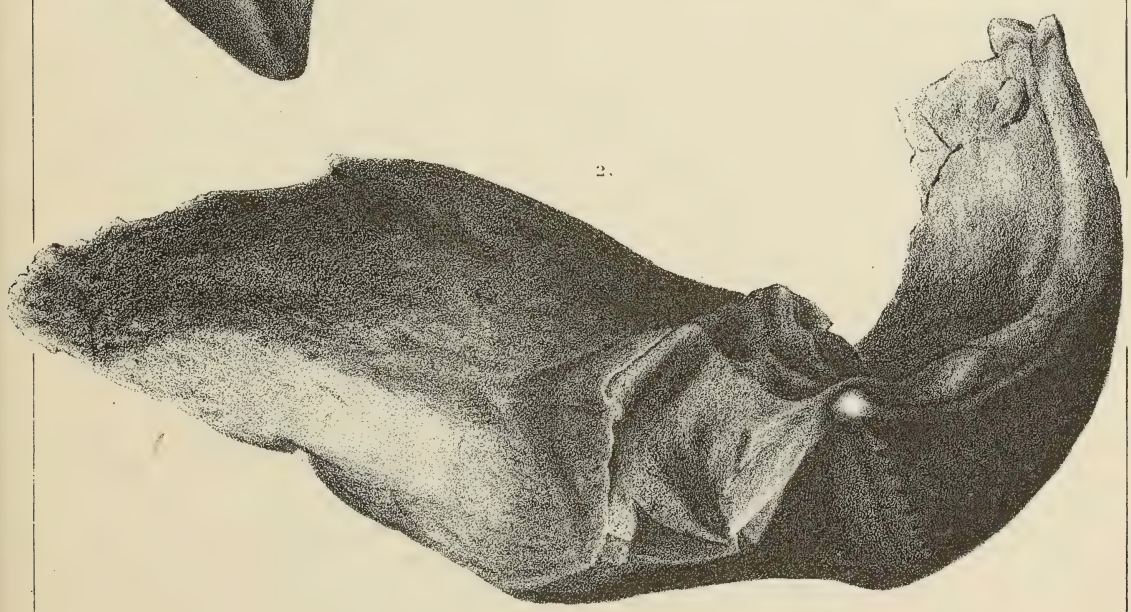


PLATE XXXII.

PAGE.

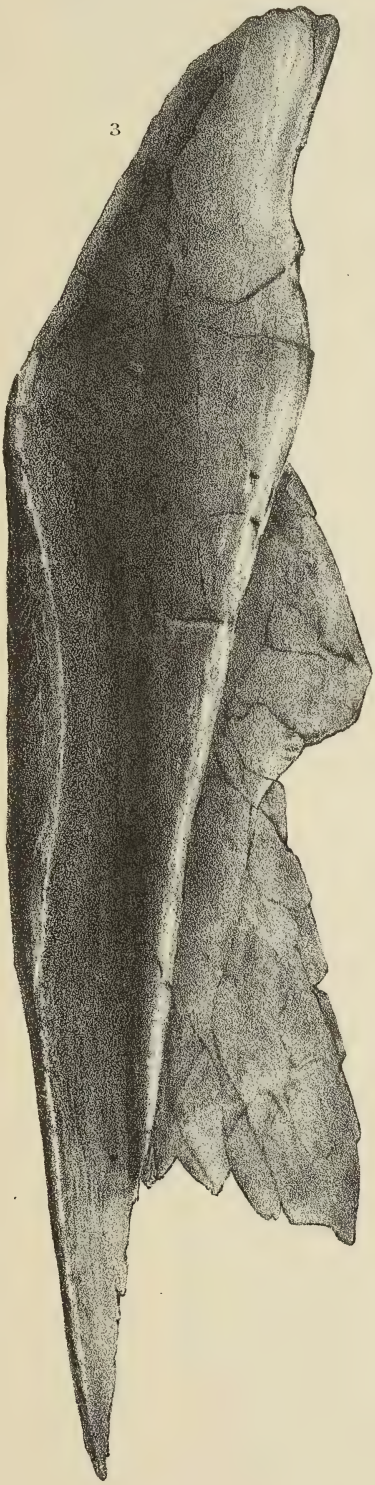
DINICHTHYS HERTZERI. Newb..... 316

Fig. 1. Dorso-median plate, external surface.
1 *a*. Transverse section through middle of plate, one-eighth natural size. Original twenty-three inches broad.

Fig. 2. Internal face of dorso-median plate showing strong median keel, one-eighth natural size.

Fig. 3. Perspective view of interior surface of dorso-median plate, one-fourth natural size, linear.

From Huron Shale, near Avon Point, Lorain County, Ohio.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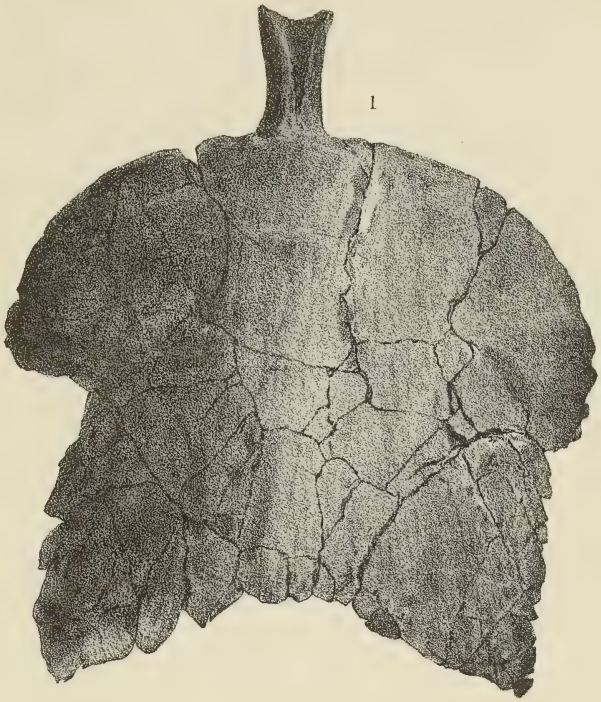
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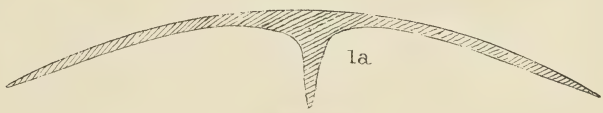

1a

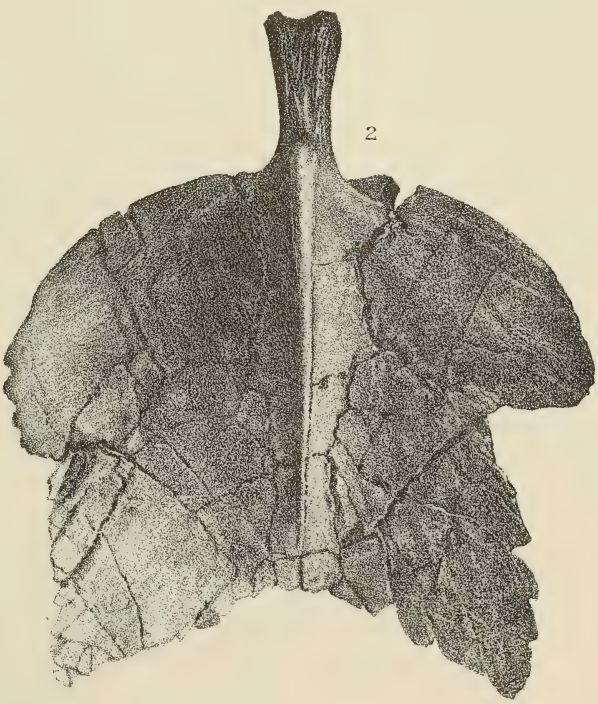

2

PLATE XXXIII.

PAGE.

DINICHTHYS HERTZERI. Newb..... 316

Fig. 1. Posterior portion of cranium, exterior surface, about one-third natural size, linear.

Fig. 2. Posterior portion of cranium, interior view, one-third natural size, linear.

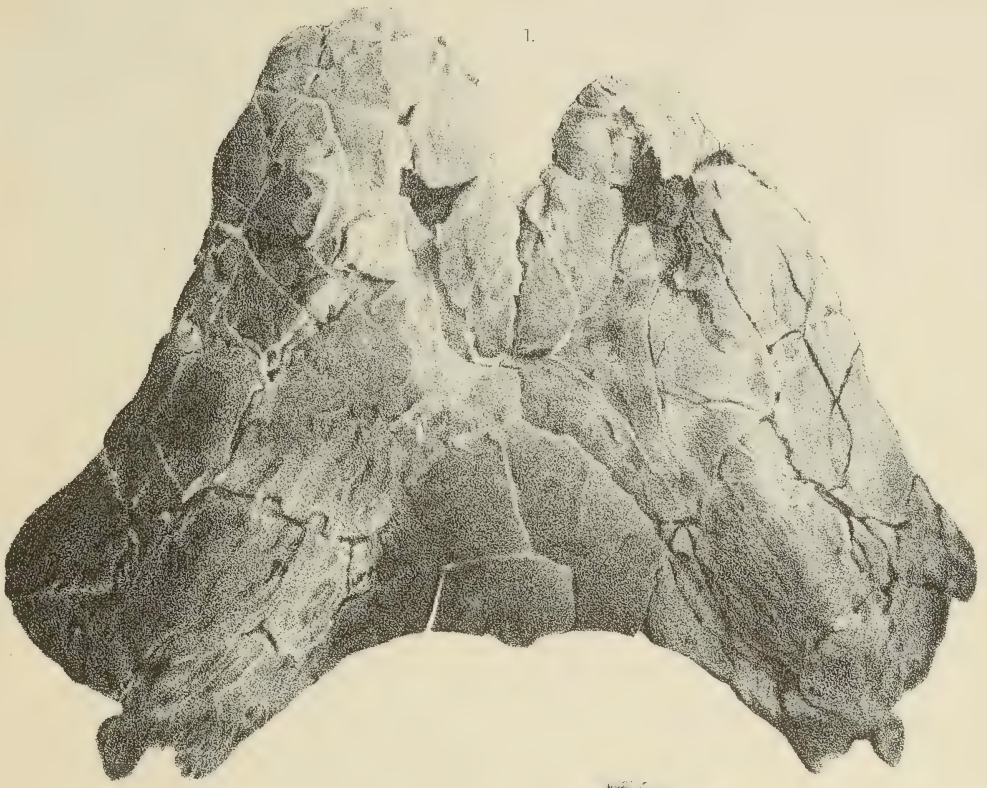
The largest specimen found of the cranium of *Dinichthys Hertzeri* is twenty-four inches wide near its posterior extremity.

Huron Shale, Sheffield, Lorain County, Ohio.

Geological Survey of Ohio,

(Huron Shale.)

1.



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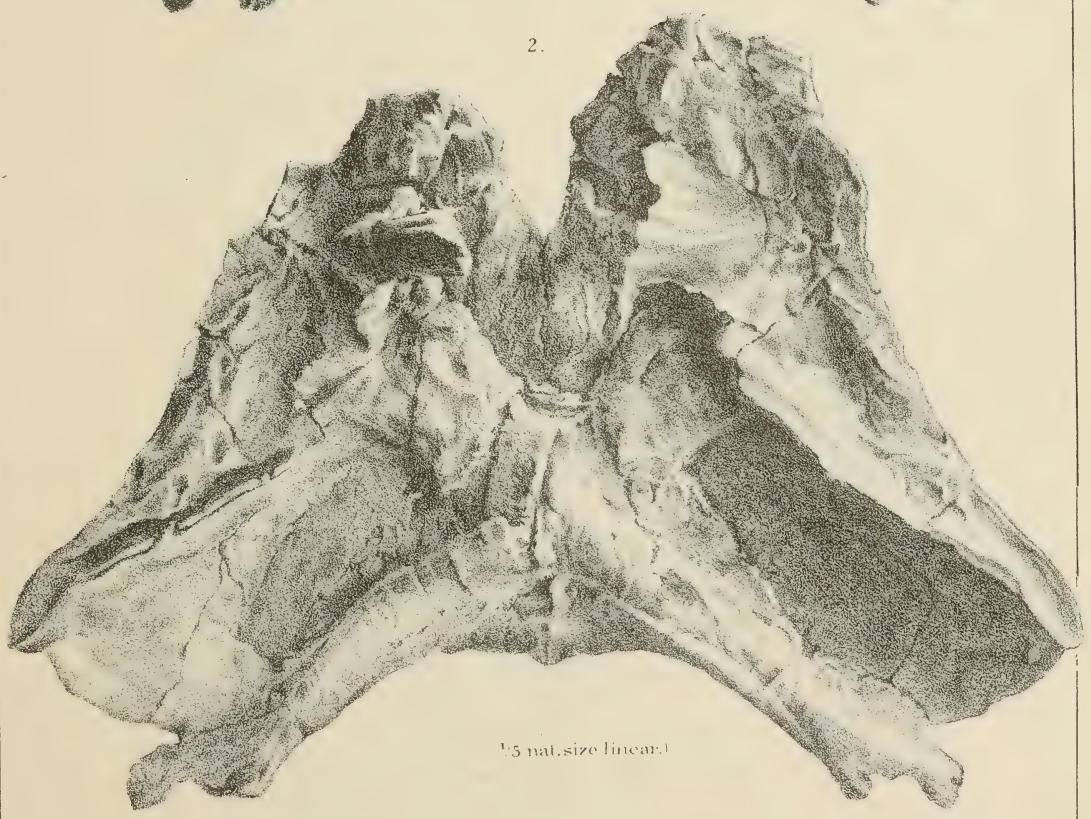


[.5 nat. size linear.]

Th^s Sinclair & Son lith Phila.

PLATE XXXIV.

PAGE.

DINICHTHYS HERTZERI. Newb..... 316

Fig 1. Supra-scapular of right side, interior face, one-fifth natural size, linear.
1 *a*. Anterior edge of Fig. 1.

Fig. 2. Supra-scapular of left side, interior face, one-fifth natural size, linear.
2 *a*. Exterior face of Fig. 2.

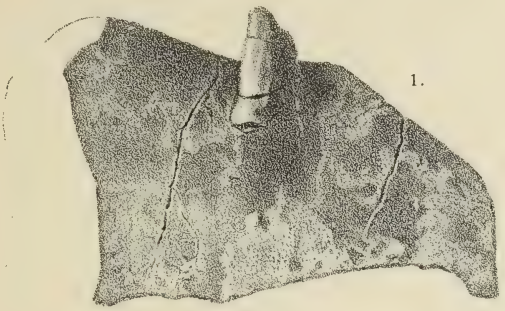
Fig. 3. *Os articulare capitis* of right side (right posterior angle of head), exterior face, one-fifth natural size.
3 *a*. Interior face of Fig. 3.
3 *b*. Posterior edge of Fig. 3, profile view, showing articulation with Fig. 1 *a*.

Fig. 4. *Os articulare capitis* of left side, interior face, one-fifth natural size, from same individual as Figs. 2 and 3.

All from Huron Shale, Sheffield, Lorain County, Ohio.

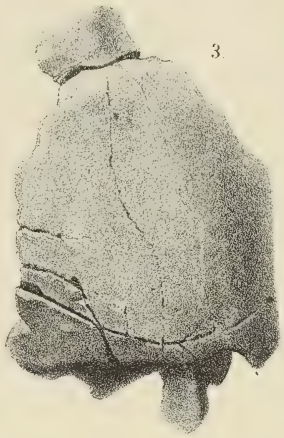
Geological Survey of Ohio.

(Huron Shale.)



1.

1a.



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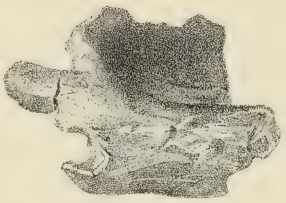

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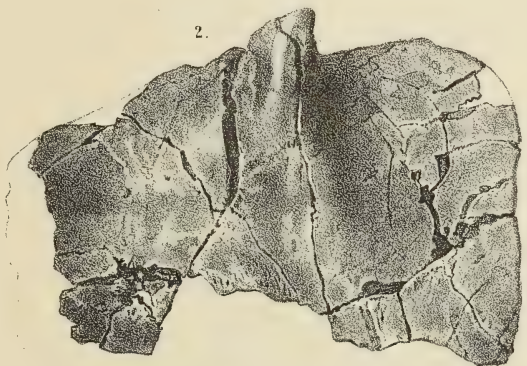

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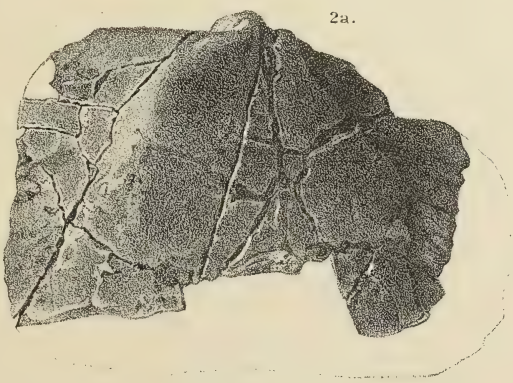
3b.



2a.

3a.

1/5 nat. size. Linear.

Th^{s} Sinclair & Son, lith. Phila

PLATE XXXV.

PAGE.

Fig. 1. ASPIDICHTHYS CLAVATUS. Newb 323

Dorso-median shield, one-fourth natural size, linear. (Size of incomplete plate, seventeen by thirteen inches.)
Huron Shale, Delaware, Ohio.

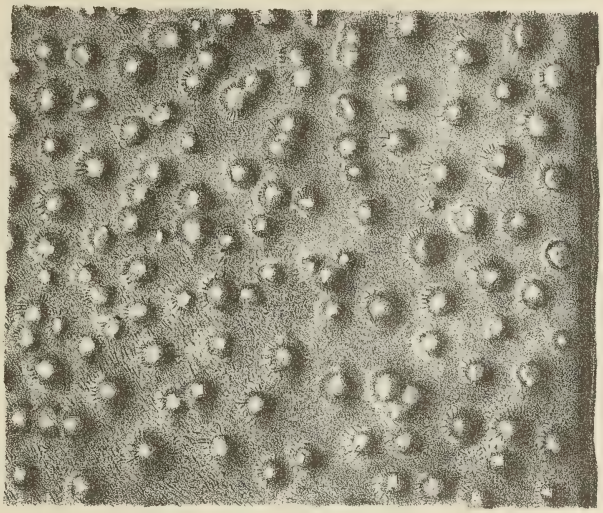
Fig. 2. ASPIDICHTHYS CLAVATUS. Newb 323

Portion of dorsal shield drawn natural size, to show tuberculation.
Huron Shale, Delaware, Ohio.

Fig. 3. CTENACANTHUS VETUSTUS. Newb 326

Side view, natural size.
3 *a* to 3 *d*. Sections of same.

Huron Shale, Sheffield, Lorain County, Ohio.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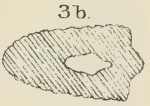
3a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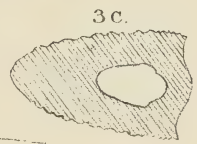
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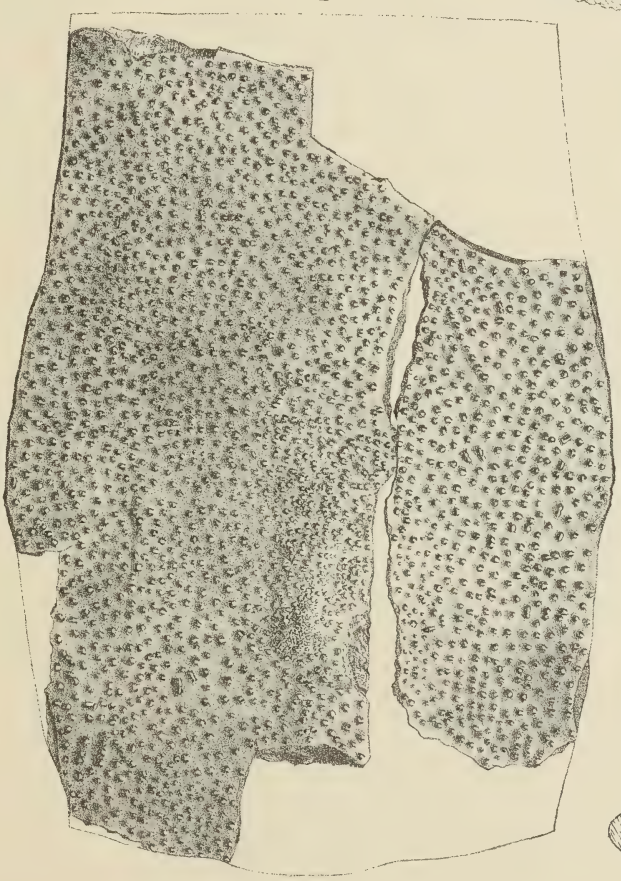
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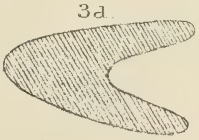

3d

PLATE XXXVI.

PAGE.

Fig. 1. CTENACANTHUS TRIANGULARIS. Newb. 329

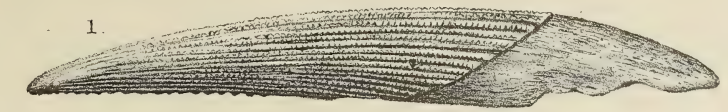
Lateral surface.
1 *a*. Posterior face.
1 *b*. Section.
All natural size.
Waverly, Oil Creek, Penn.

Fig. 2. CTENACANTHUS FORMOSUS. Newb. 328

Lateral surface, natural size.
2 *a*. Posterior face, showing denticles magnified.
2 *b*. Lateral surface magnified.
Waverly, Vanceburgh, Ky.

Fig. 3. CTENACANTHUS MARSHI. Newb 326

Lateral surface.
3 *a*. Posterior face, natural size.
3 *b*. Section.
Coal Measures, Zanesville, Ohio.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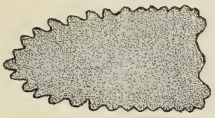
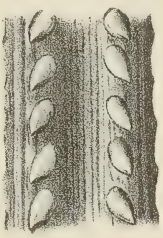
1b.

1a.


3b.

2b.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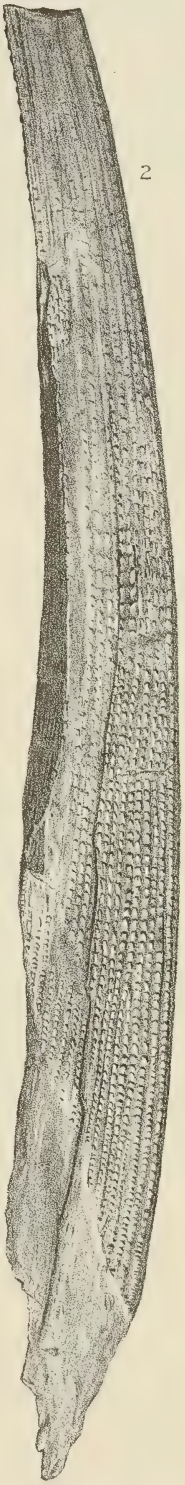
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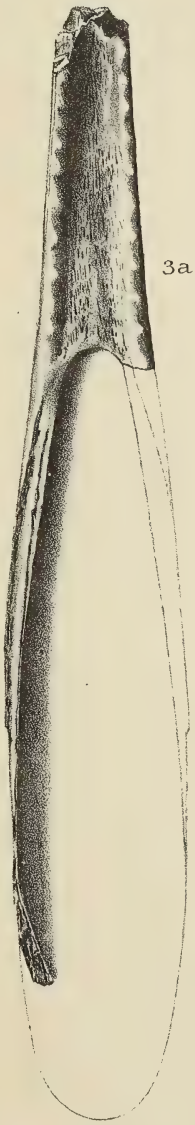
3a.

3

PLATE XXXVII.

PAGE.

Fig. 1. GYRACANTHUS COMPRESSUS. Newb..... 330

Lateral surface.
1 *a*, 1 *b*. Sections of the same.

Fig. 2. GYRACANTHUS COMPRESSUS. Newb..... 330

Fragment of a large specimen from Dearborn, Indiana, lateral surface.
2 *a*. Posterior face of same.
2 *b*. Section of same.

Fig. 3. GYRACANTHUS ALLENI. Newb..... 331

Lateral surface.
3 *a*. Posterior face.
3 *b*. Anterior face, showing exposed and inserted portions.
3 *c*, 3*d*. Sections of same.

Figs. 1 and 3 from Cuyahoga Shale (Waverly), Bagdad, Medina County, Ohio.

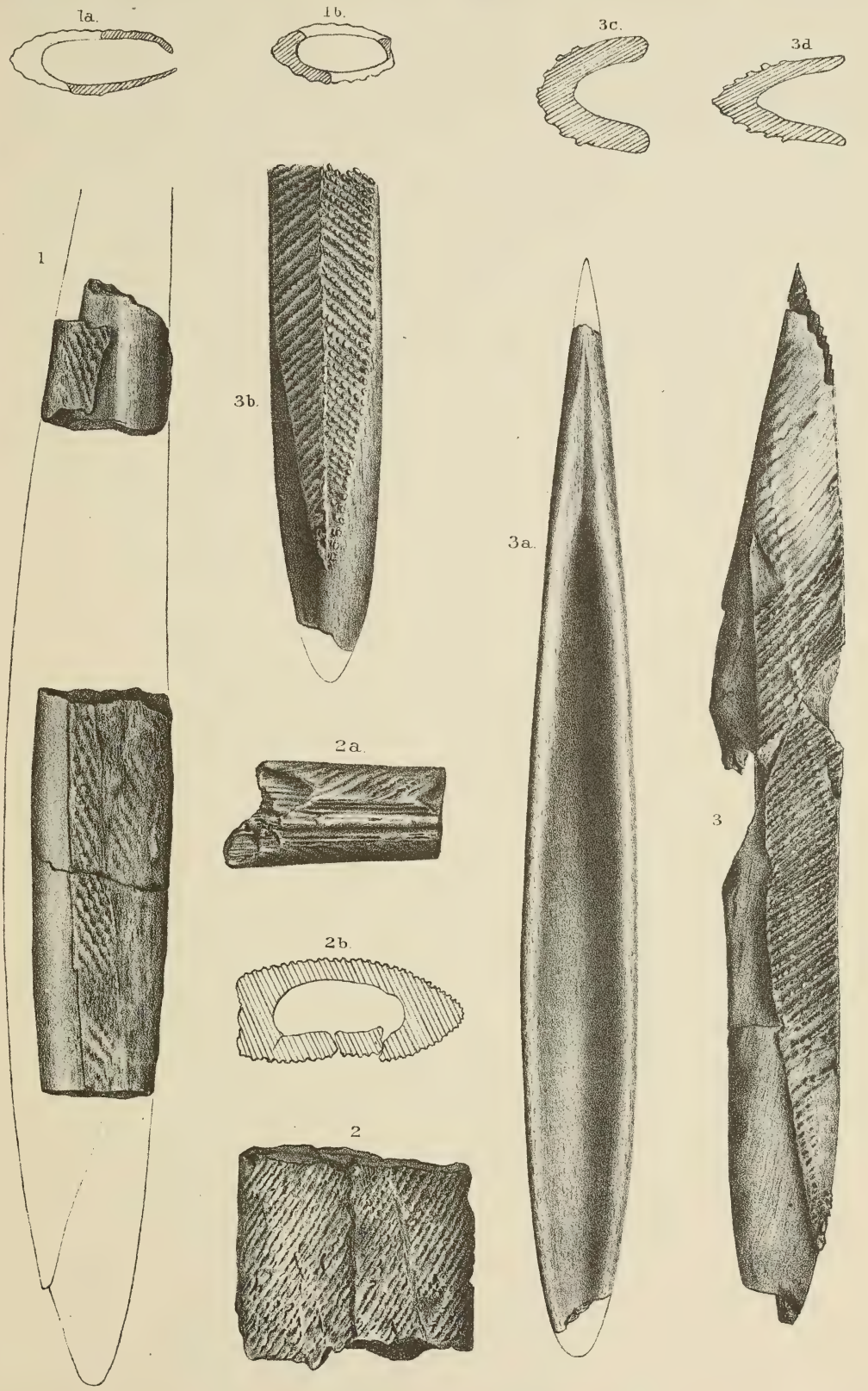
1a.
1b.
3c.
3d.
1
3b.
3a.
3
2a.
2b.
2

PLATE XXXVIII.

PAGE.

Fig. 1. PALÆONISCUS PELTIGERUS. Newb. 345

1 *a*, 1 *b*. Scales of same.

Fig. 2. EURYLEPIS TUBERCULATUS. Newb. 350

2 *a*, 2 *b*. Scales of same, enlarged.
2 *c*. Cranial plates of same, enlarged to show ornamentation.

Fig. 3. EURYLEPIS TUBERCULATUS. Newb. 350

Another individual.
3 *a*. Scale, enlarged.

Fig. 4. EURYLEPIS CORRUGATUS. Newb. 350

4 *a*. Scale of same.

Fig. 5. Tail of a Crustacean.

All from Cannel Coal forming bottom of Coal Seam No. 6, Linton, Jefferson County, Ohio.

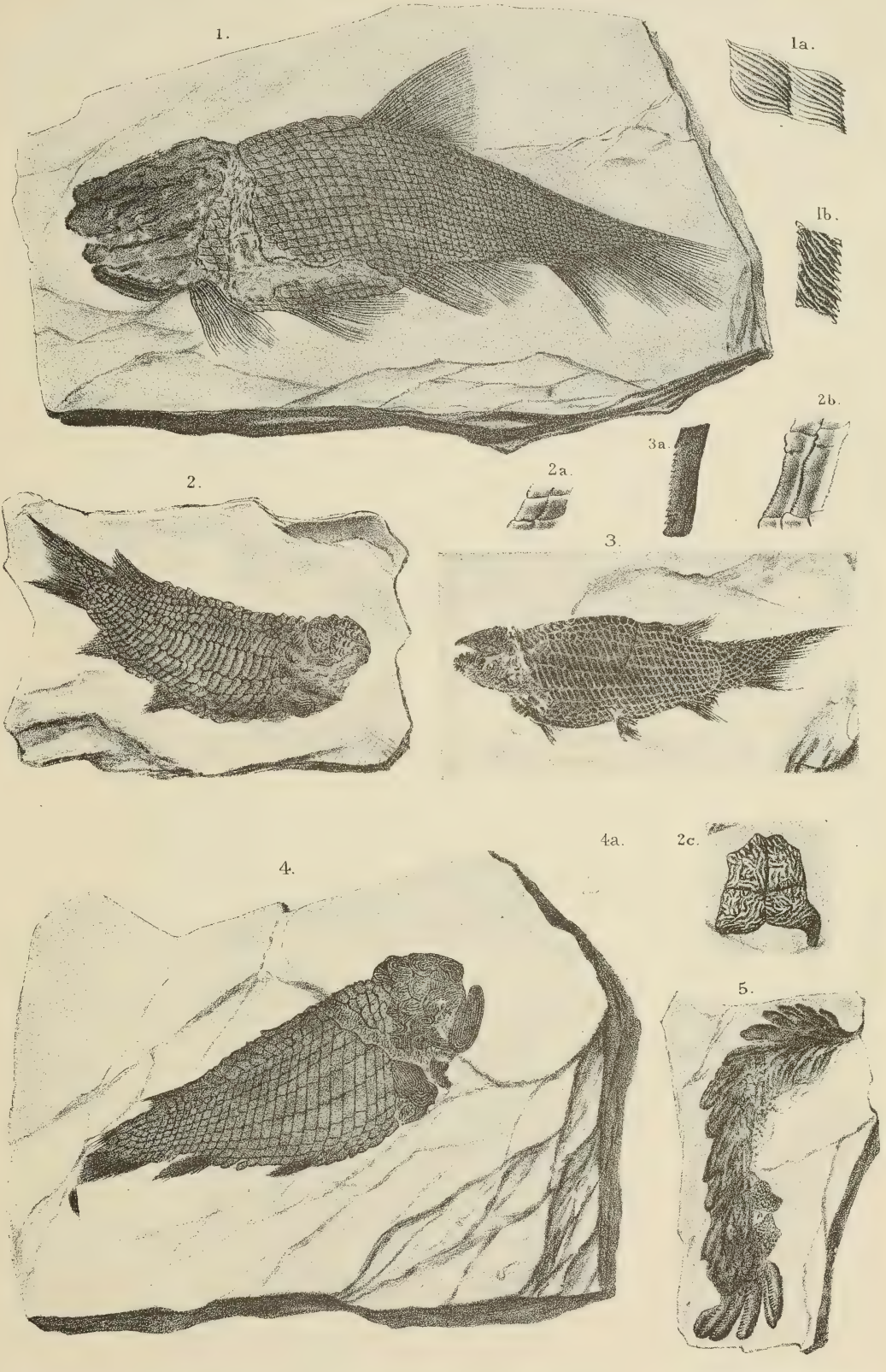
1.
1a.
1b.
2.
2a.
2b.
3.
3a.
4.
4a.
2c.
5.

PLATE XXXIX.

PAGE.

Fig. 1. EURYLEPIS OVOIDEUS. Newb 351

Natural size.

Fig. 2. EURYLEPIS INSCULPTUS. Newb 351

Natural size.
2 *a*. Scale of same, enlarged to show ornamentation.

Fig. 3. EURYLEPIS MINIMUS. Newb 353

Natural size.

Fig. 4. EURYLEPIS ORNATISSIMUS. Newb 352

Natural size.
4 *a*. Scale of same, enlarged.

Fig. 5. EURYLEPIS GRANULATUS. Newb 352

Natural size.
a. Scale of same, enlarged.

Fig. 6. RHIZODUS ANGUSTUS. Newb 342

Portion of jaw with attached teeth, natural size.

Fig. 7. EURYLEPIS LINEATUS. Newb 353

Natural size.
7 *a*. Scale of same, enlarged.

Fig. 8. RHIZODUS QUADRATUS. Newb 343

Scale, natural size.

Fig. 9. RHIZODUS LANCIFER. ewb 342

Tooth, natural size.

All from Cannel Coal forming base of Coal Seam No. 6, Linton, Jefferson County, Ohio.

1.

2.

3.

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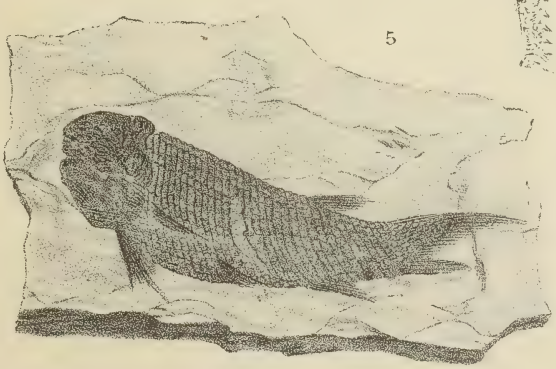
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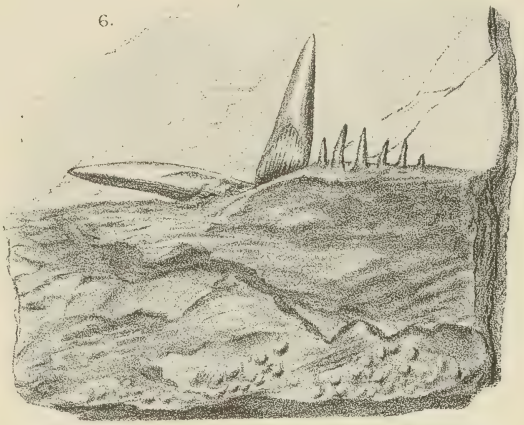
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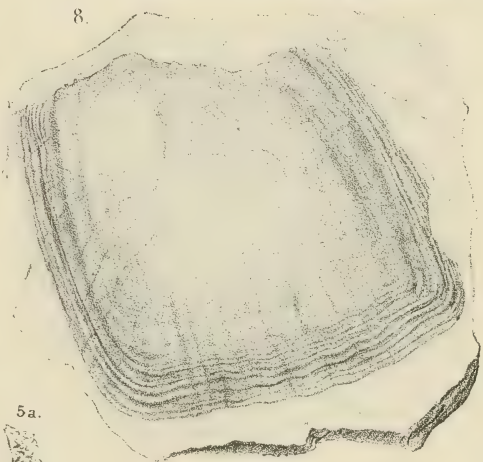
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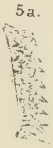

5a.

7a.

PLATE XL.

PAGE.

Fig. 1. CŒLACANTHUS ELEGANS. Newb..... 339

1 *a*. Jugular plate of same.
1 *b*. Scales enlarged to show ornamentation.
1 *c*. Cranial plate of *C. elegans*.
1 *d*. Operculum of same.

Fig. 2. CŒLACANTHUS ROBUSTUS. Newb..... 341

Jugular plate, natural size.
2 *a*. Scale, showing ornamentation of exposed and covered portions of surface, natural size.

Fig. 3. MEGALICHTHYS. Agass..... 343

Scale, natural size.
3 *a*. Another scale of same.

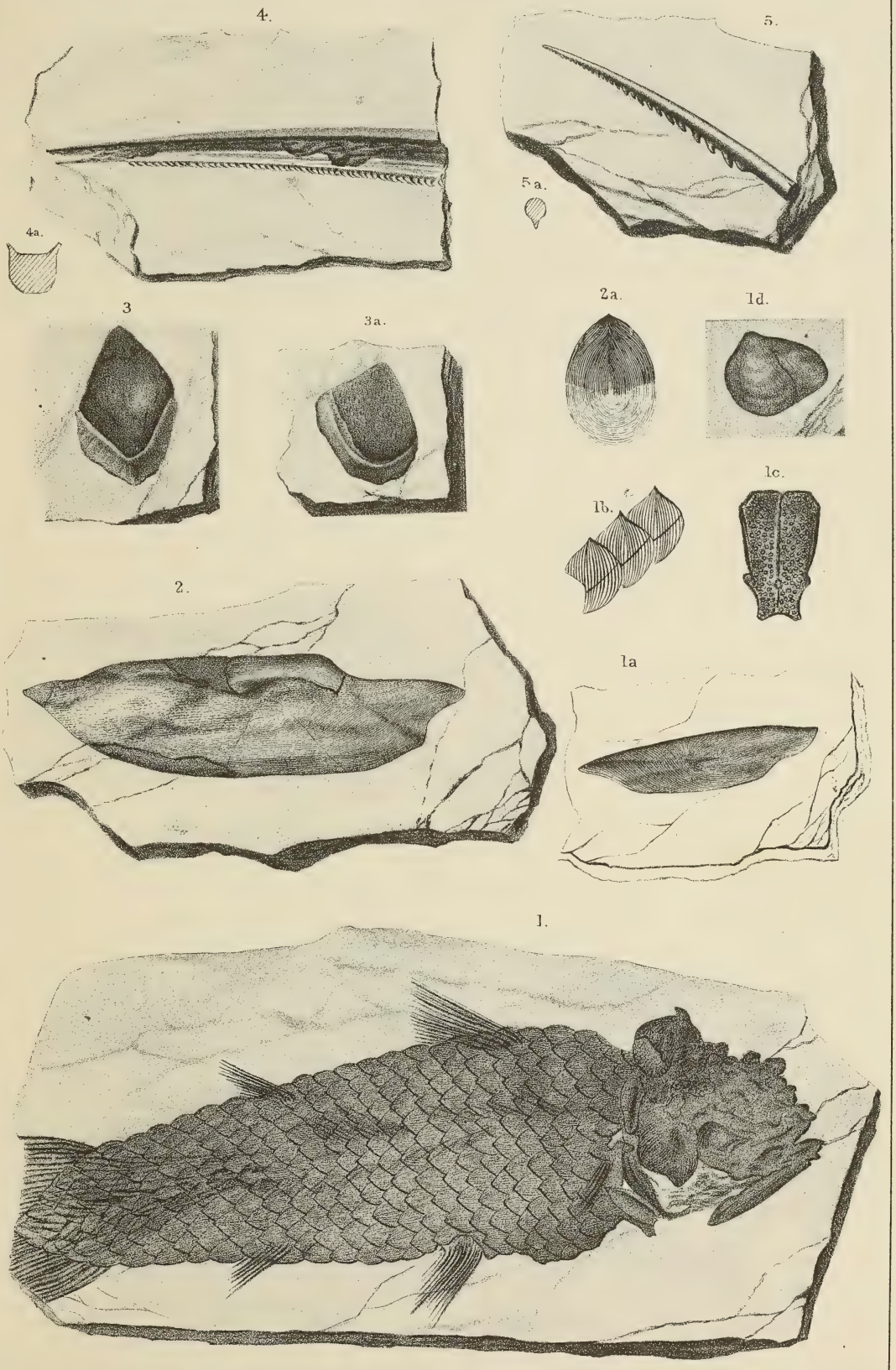
Fig. 4. ORTHACANTHUS ARCUATUS. Newb..... 332

Spine, showing one row of denticles.
4 *a*. Section of same, natural size.

Fig. 5. COMPSACANTHUS LÆVIS. Newb..... 332

5 *a*. Section of same, natural size.

All from Coal No. 6, Linton, Jefferson County, Ohio.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2a.
1d.
1c.
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PLATE XLI.

PAGE.

Fig. 1. ANTHOLITHES PITCAIRNIÆ? L. and H.....

Fig. 2. ANTHOLITHES?.....

With last, and probably more mature state.
Youngstown, Ohio.

Fig. 3. ANTHOLITHES PRISCUS. Newb..... 363

From over Coal No. 1, Youngstown, Ohio.

Fig. 4. CARDIOCARPON. Brongt..... 370

Stems bearing Cardiocarpa, associated with Cordaites.
From over Coal No. 1, Youngstown, Ohio.

Fig. 5. POLYSPORIA MIRABILIS. Newb..... 362

Cone, showing arrangement of sporangia.
5 *a*. Detached sporangium, containing microspores

Fig. 6. POLYSPORIA MIRABILIS. Newb..... 362

Summit of cone surrounded by a mass of spores, escaped from the sporangia.

Roof of Coal No. 1, Tallmadge, Summit County, Ohio.

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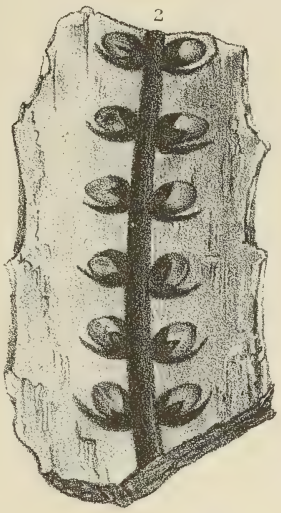
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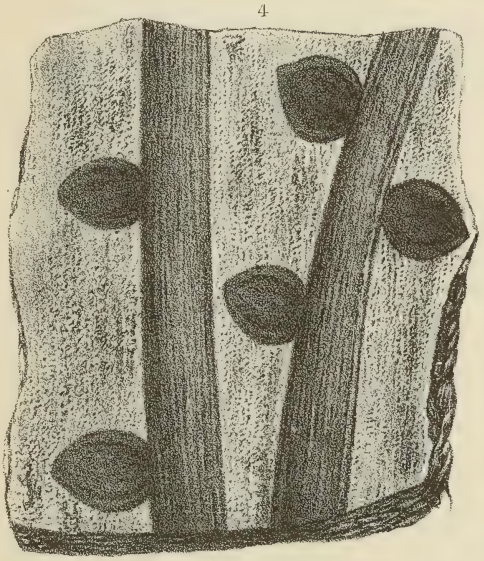
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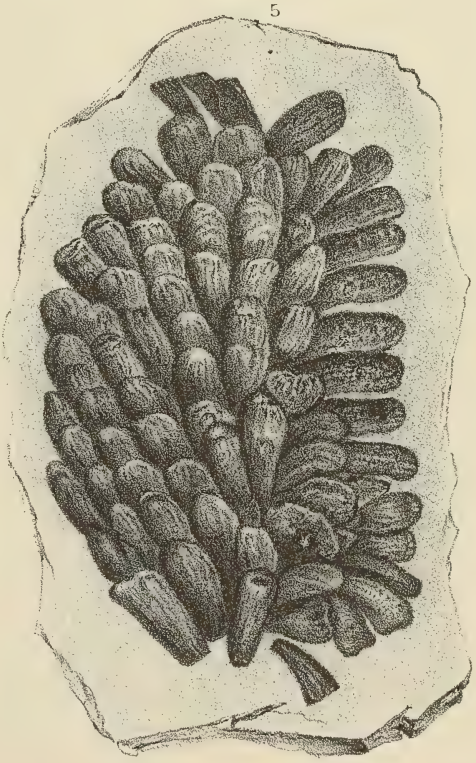
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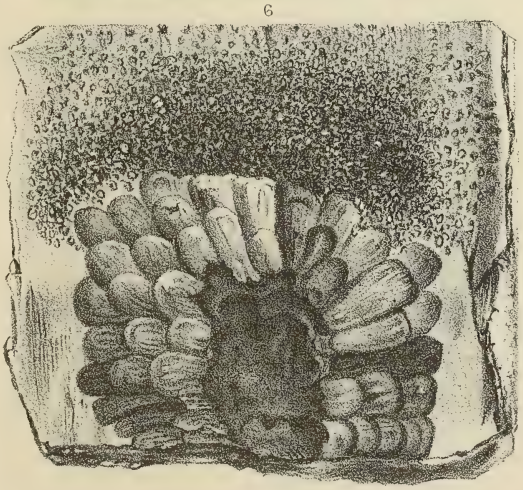
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PLATE XLII.

PAGE.

Fig. 1. TRIGONOCARPON TRILOCULARE. Hildreth..... 367
Showing the wings.

Fig. 2. TRIGONOCARPON TRICUSPIDATUM. Newb..... 368
Complete nut.

Fig. 3. TRIGONOCARPON TRICUSPIDATUM. Newb..... 368
Nucleus of nut.

Fig. 4. TRIGONOCARPON TRICUSPIDATUM. Newb..... 368
Another specimen. Nucleus of nut.

Fig. 5. TRIGONOCARPON..... 366
Portion of rind of drupaceous fruit which enclosed *Trigonocarpon*. Flower end.

Fig. 6. TRIGONOCARPON..... 366
Same, showing impression of stem.

Fig. 7. TRIGONOCARPON ORNATUM. Newb..... 368
7 *a*. Basal end of Fig. 7.

Fig. 8. TRIGONOCARPON MULTICARINATUM. Newb..... 369
8 *a*. Upper end of Fig. 8.

Fig. 9. TRIGONOCARPON..... 366
Nut inclosed in drupaceous fruit.

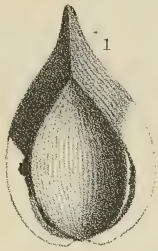
Fig. 10. TRIGONOCARPON..... 366
Inclosed in drupaceous fruit.

Fig. 11. TRIGONOCARPON MAGNUM. Newb..... 369
11 *a*. Basal end of same.
Sandstone over Coal No. 6, Coshocton, Ohio.

Fig. 12. TRIGONOCARPON BERTHOLLETIFORME. Foster..... 369
12 *a*. Another view of same.
Coal Measures, Zanesville, Ohio.

Fig. 13. TRIGONOCARPON TRILOCULARE. Hildreth..... 367
13 *a*. Basal view of same.
All figures on this plate natural size.

Figs. 1, 7, 8 and 13 from Conglomerate, Cuyahoga Falls, Ohio. Figs. 2, 3, 4, 5, 6, 9 and 10 from over Coal No. 1. Tallmadge, Ohio.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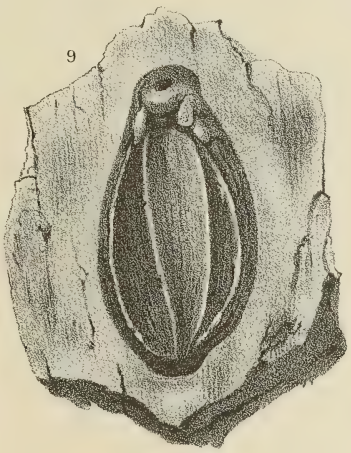
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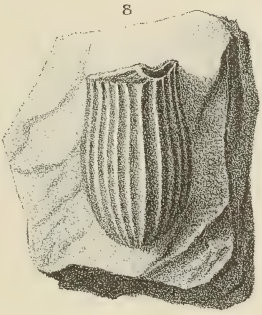
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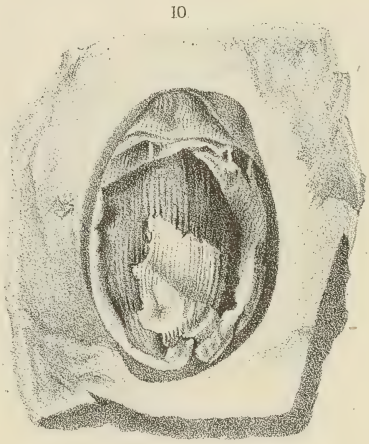
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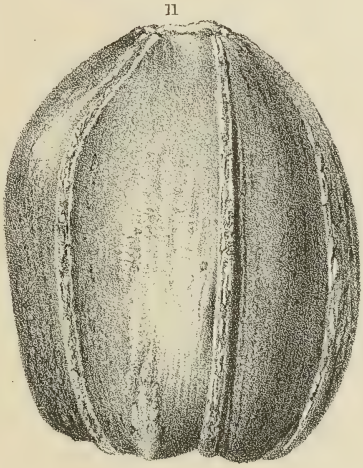
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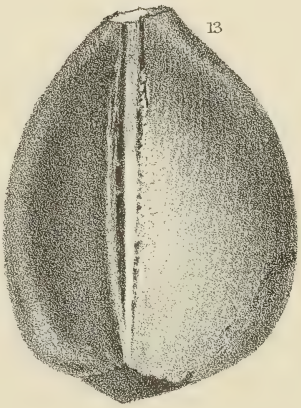
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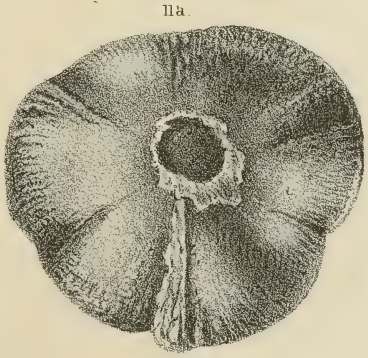
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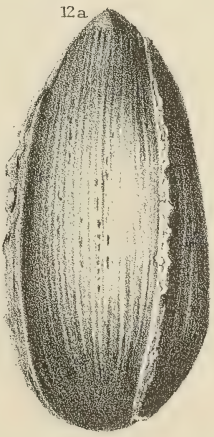
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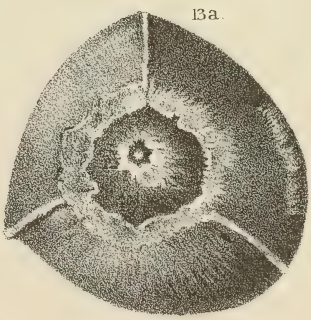

13a

PLATE XLIII.

PAGE.

Fig. 1. CYCAS REVOLUTA (living) 371

Entire fruit. Compare with Figs. 8, 8 *a*.

1 *a*. Nut contained in same.

Fig. 2. CARPOLITHUS FRAGARIOIDES. Newb..... 370

External envelope, the nucleus having escaped.

2 *a*. Nucleus of same.

Fig. 3. CARDIOCARPON LATUM. Newb 372

Fig. 4. CARDIOCARPON MINUS. Newb. 372

Fig. 5. CARDIOCARPON ELONGATUM. Newb 373

Fig. 6. CARDIOCARPDN RETUSUM. Sternbg.. 374

Fig. 7. CARDIOCARPON MARGINATUM. Foster..... 373

Fig. 8. CARDIOCARPON ANNULATUM. Newb 374

8 *a*. Another specimen of the same.

Fig. 9. CARDIOCARPON BICUSPIDATUM. Sternbg..... 373

9 *a*. Smaller specimen of same.

Fig. 10. CARDIOCARPON ORBICULARE. Newb 374

Fig. 11. CARDIOCARPON SAMARÆFORME. Newb..... 375

11 *a*. Another specimen of the same.

Fig. 12. TRIGONOCARPON .....

Drapaceous fruit inclosing *Trigonocarpon*.

Fig. 13. TRIGONOCARPON TRILOCULARE. Hildreth..... 367

Basal end of compressed specimen showing nucleus.
Conglomerate, Cuyahoga Falls, Ohio.

Fig. 14. TRIGONOCARPON 367

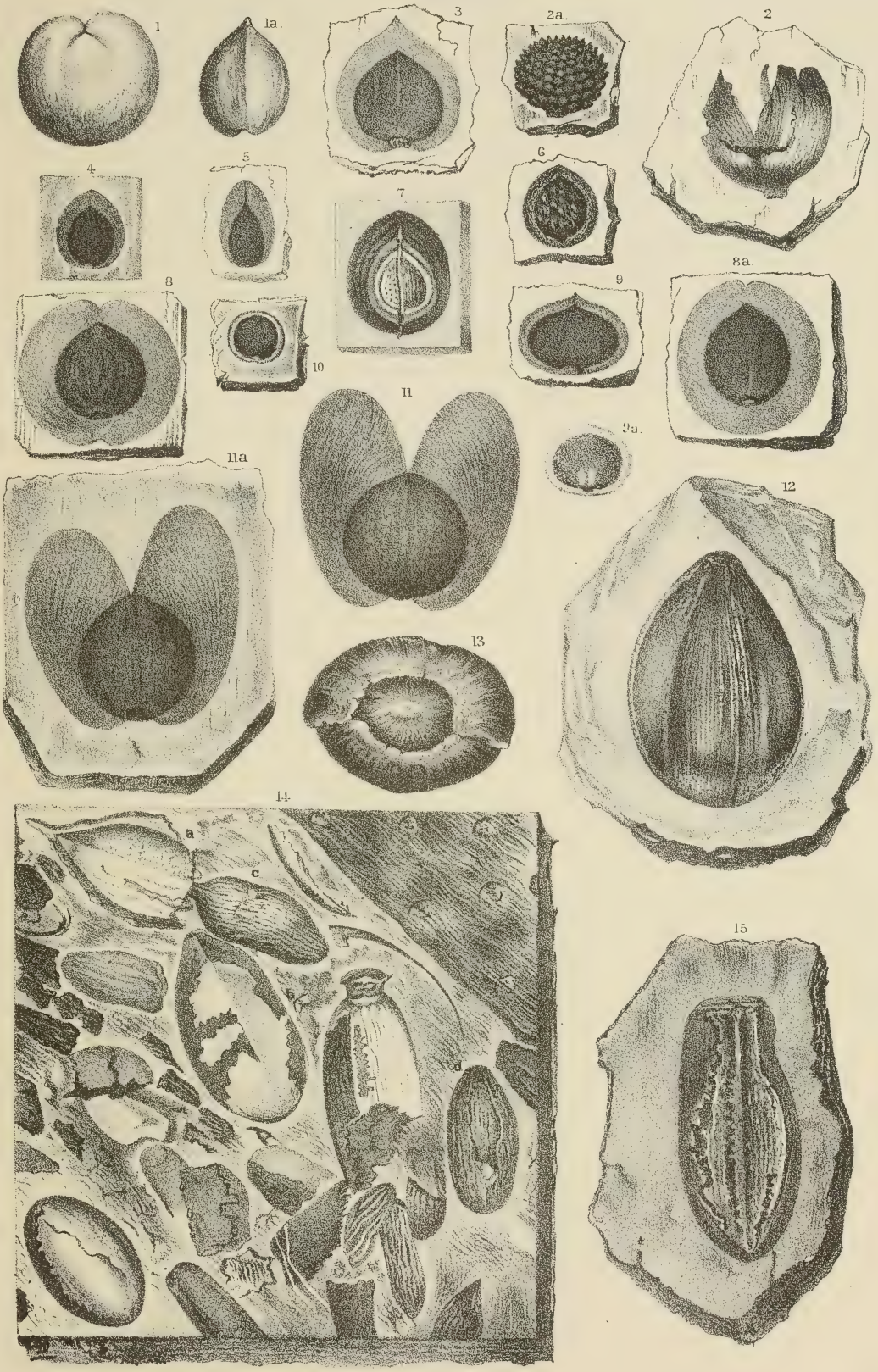
Group of fragments, showing (*a*, *b*) segments of shell (*c*, *d*) nuclei.

Fig. 15. TRIGONOCARPON 366

Outline of drupaceous fruit, showing inclosed nut.

All figures on this plate natural size.

All specimens excepting 1, 1 *a*, 7 and 13 from shale over Coal No. 1, Summit and Mahoning counties, Ohio.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11
9a.
11a
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14
a
c
b
d
15

PLATE XLIV.

PAGE.

Fig. 1. TRIGONOCARPON 366
Showing portion of fleshy envelope.

Fig. 2. TRIGONOCARPON 366
Entire fruit, inclosing nut.

Fig 3. RHABDOCARPUS CARINATUS. Newb 376
Showing portion of envelope.

Fig. 4. RHABDOCARPUS DANAI. Foster 376
Zanesville, Ohio.

Fig. 5. RHABDOCARPUS LÆVIS. Newb 377
5 *a*. Edge view of the same.
Conglomerate, Cuyahoga Falls, Ohio.

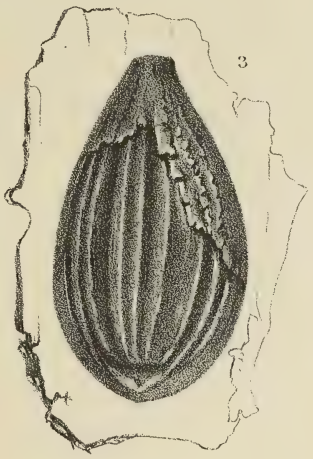
Fig. 6. RHABDOCARPUS APICULATUS. Newb 377
Over Coal No. 1, Cuyahoga Falls, Ohio.

Fig. 7. RHABDOCARPUS ACUMINATUS. Newb 378
Over Coal No. 1, Youngstown, Ohio.

Fig. 8. RHABDOCARPUS COSTATUS. Newb 378
Over Coal No. 1, Youngstown, Ohio.

All figures on this plate natural size.

Figs. 1, 2 and 3 from over Coal No. 1, Tallmadge, Ohio.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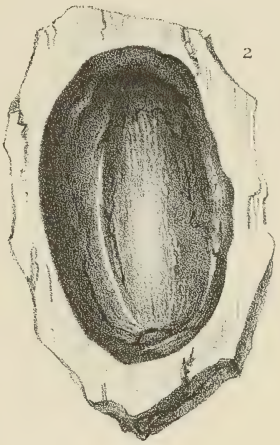
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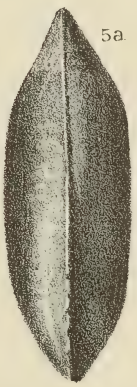
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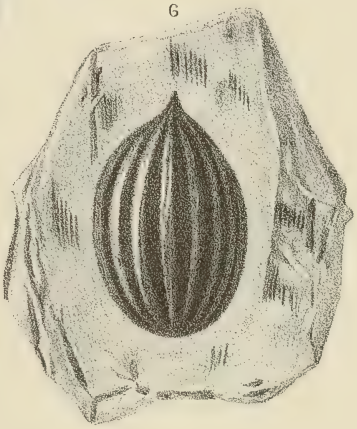
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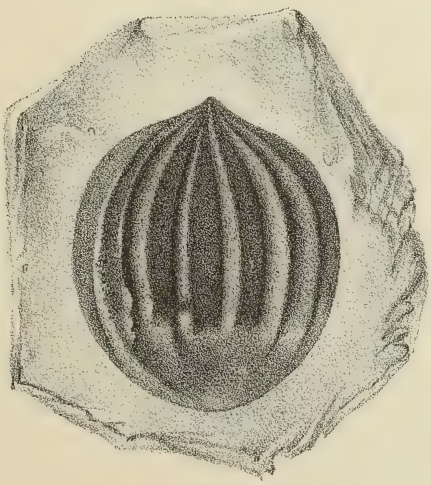
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PLATE XLV.

PAGE.

NERIOPTERIS LANCEOLATA. Newb..... 381

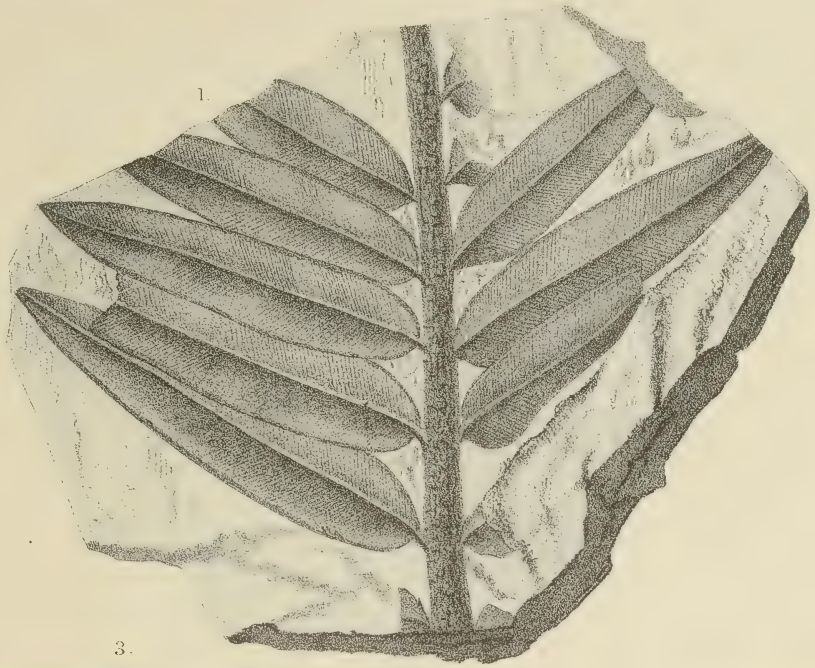
Fig. 1. Portion of frond near upper extremity.

Fig. 2. Middle portion of frond.

Fig. 3. Single pinnule. Natural size.

3 *a*. Portion of same enlarged to show nervation.

In Fig. 3 *a* the nerves are incorrectly represented as all simple, whereas they are frequently forked the base. See pp. 380, 381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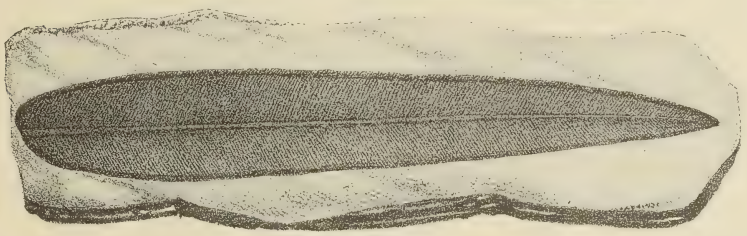
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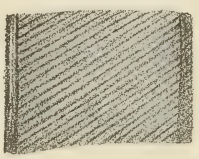
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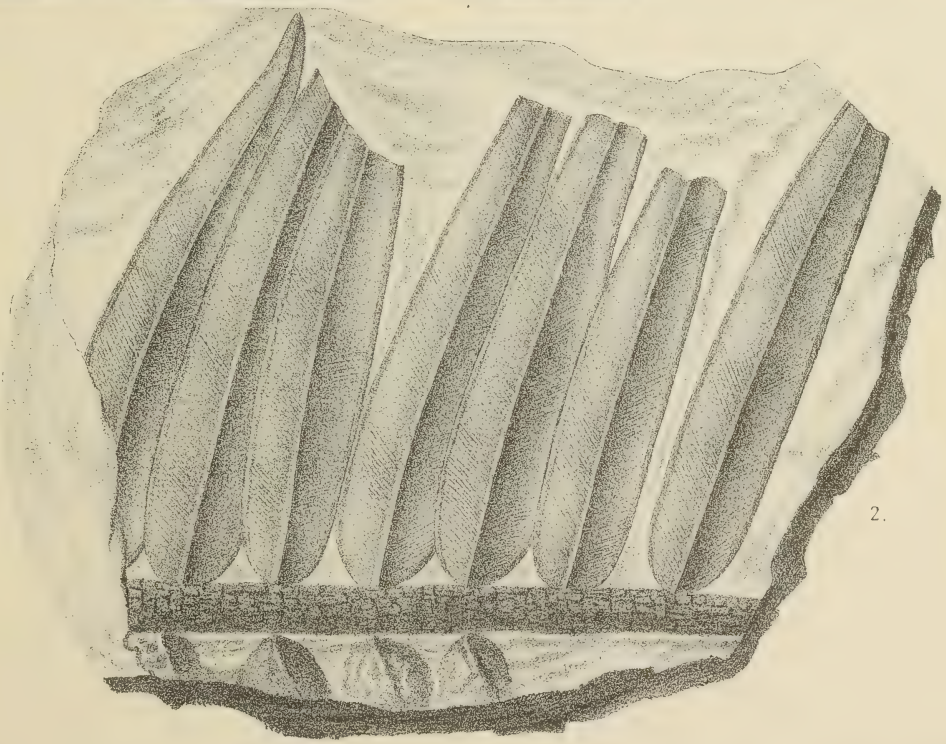
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PLATE XLVI.

PAGE.

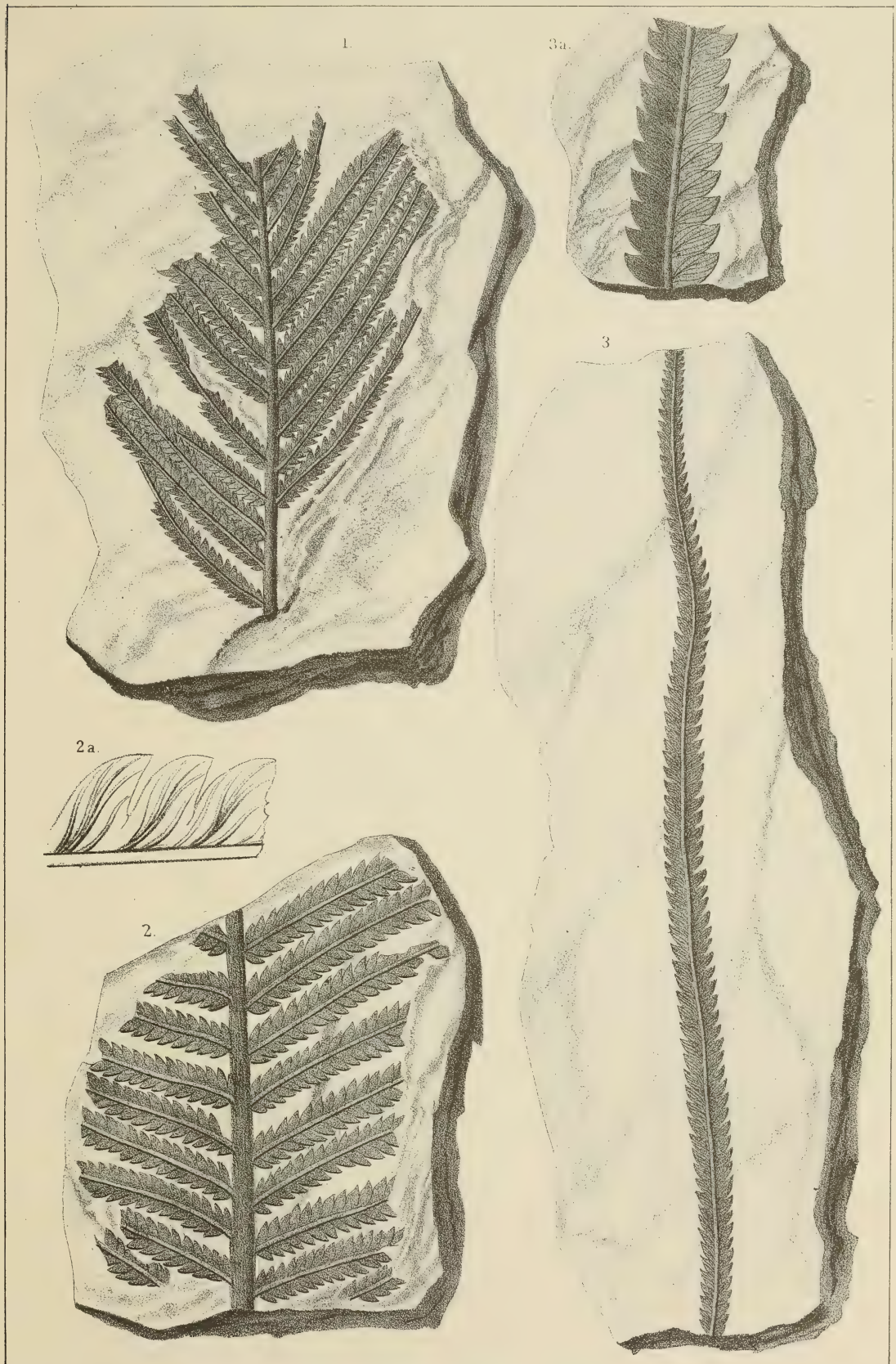
ODONTOPTERIS GRACILLIMA. Newb..... 382

Fig. 1. Portion of the summit of a frond.

Fig. 2. Middle portion of a frond.
2 *a*. Portion magnified to show nervation.

Fig. 3. A single pinna, nearly entire, from middle of a frond.
3 *a*. Portion enlarged to show nervation.

Roof shales of Coal No. 1, Youngstown, Mahoning county, Ohio.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3a.
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2a.
2.

PLATE XLVII.

PAGE.

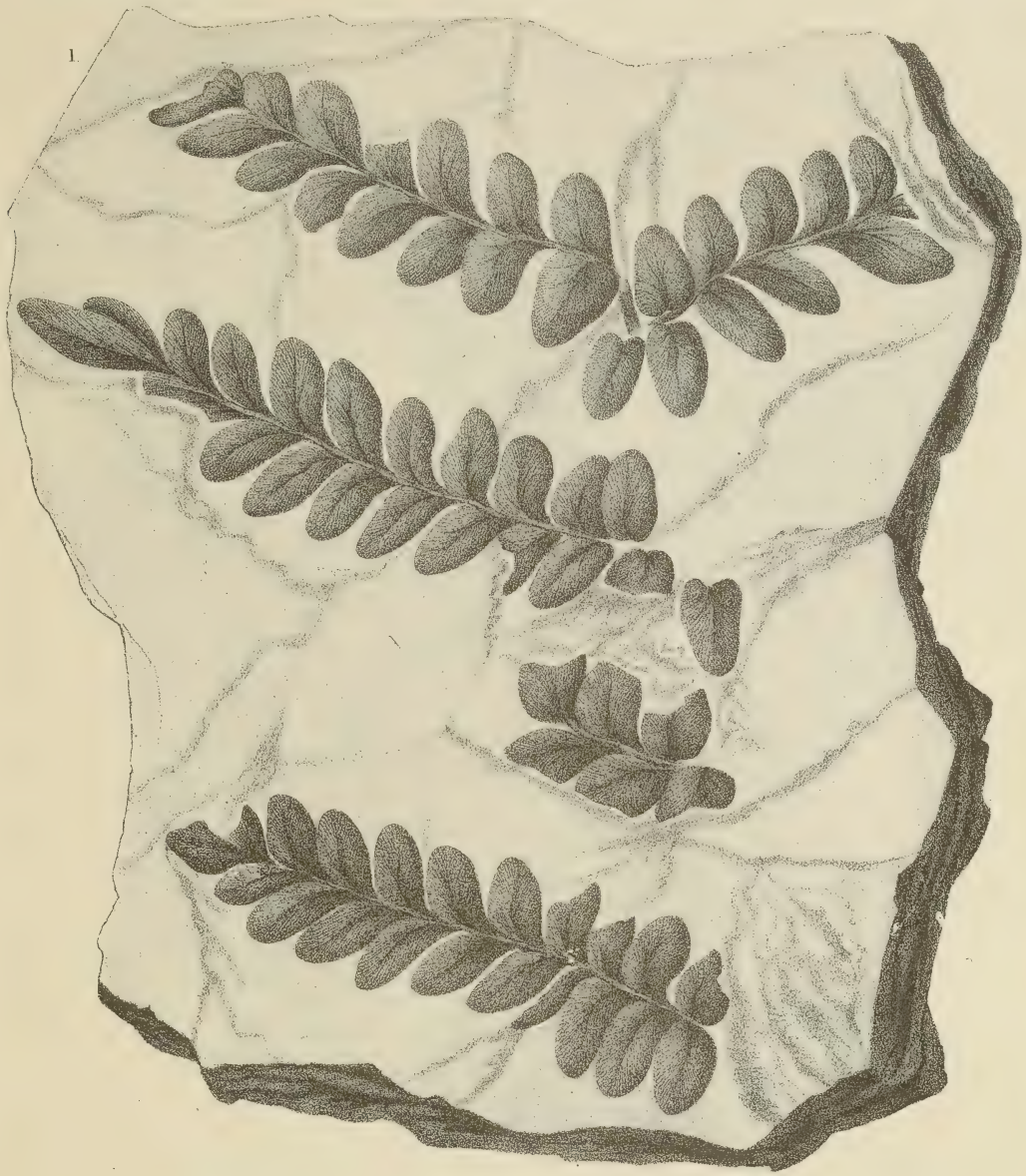
ODONTOPTERIS NEUROPTEROIDES. Newb 381

Fig. 1. Portion of frond with basal pinnules of pinnæ like Neuropteris.

Figs. 2 and 3. Pinnæ having characters of Odontopteris.

From shale over Coal No. 1, Youngstown, Ohio.

1.



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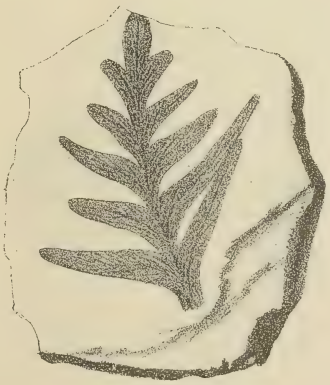


3.

W. Gardner, del.

Thos. Sinclair & Son, lith. Phila.

PLATE XLVIII.

PAGE.

Fig. 1. ALETHOPTERIS GRANDIFOLIA. Newb 384

Two pinnæ from near base of one of the subdivisions of the tri-pinnate frond of variety with narrow pinnules.

1 *a*. Two pinnules enlarged to show nervation.

Fig. 2. ALETHOPTERIS GRANDIFOLIA. Newb 384

Pinna of most common form with broad elliptical pinnules.

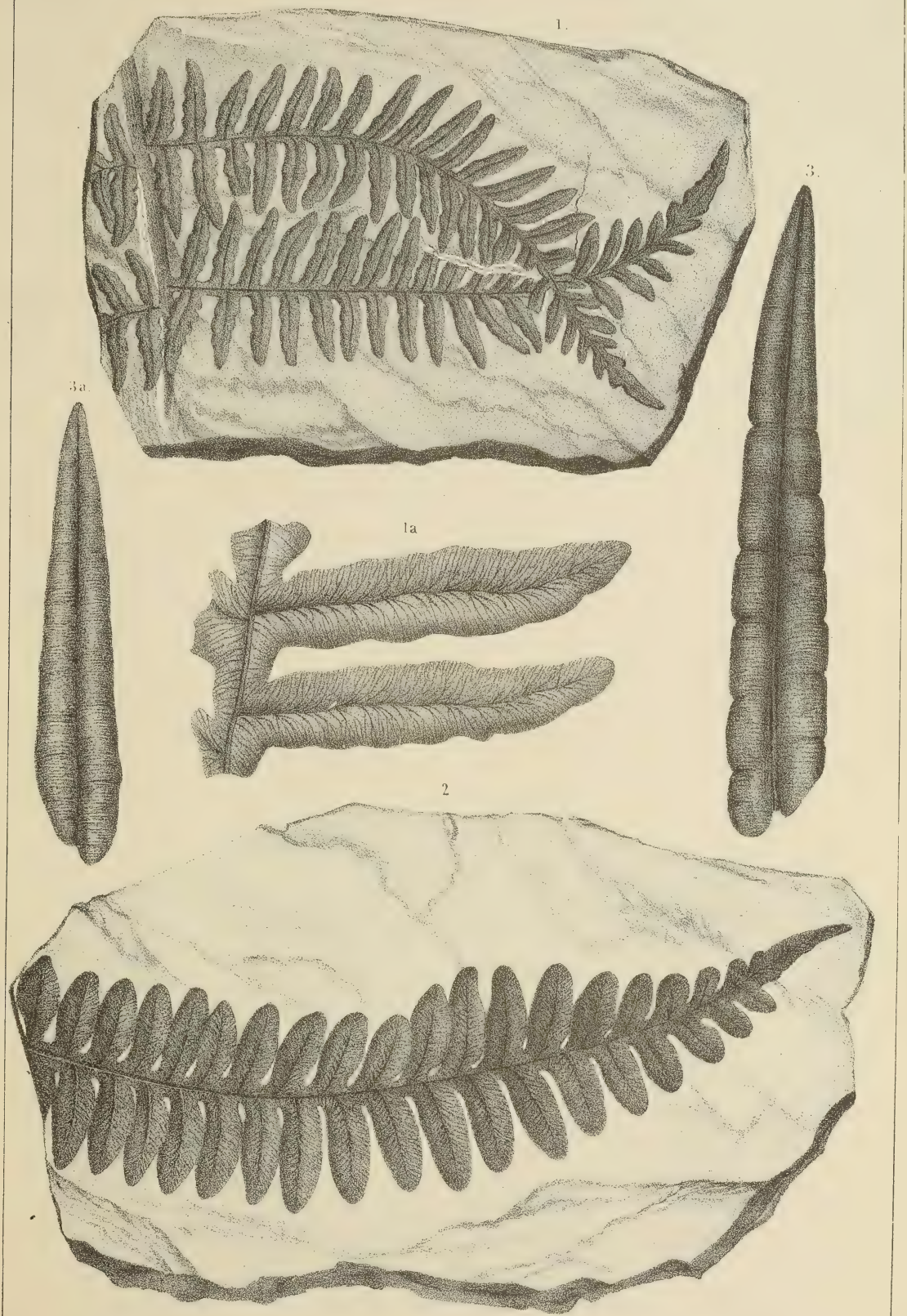
Both from Coal No. 1, Tallmadge, Summit county, Ohio.

Fig. 3. ALETHOPTERIS MACROPHYLLA. Newb 383

Single pinnule, natural size.

3 *a*. Another specimen of the same.

Over Coal No. 1, Youngstown, Ohio.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